# ENGINEERING

An Illustrated Weekly Journal

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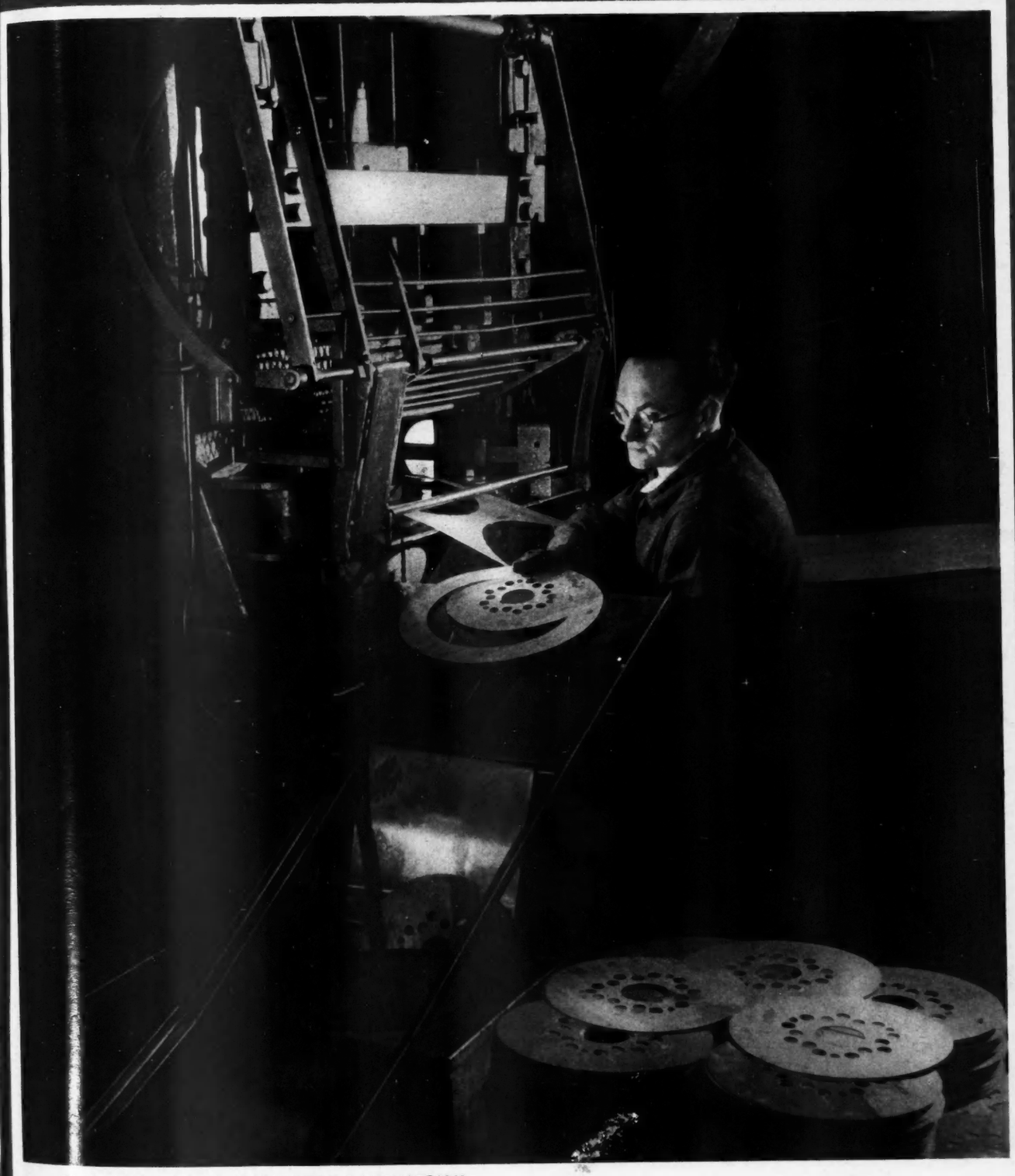
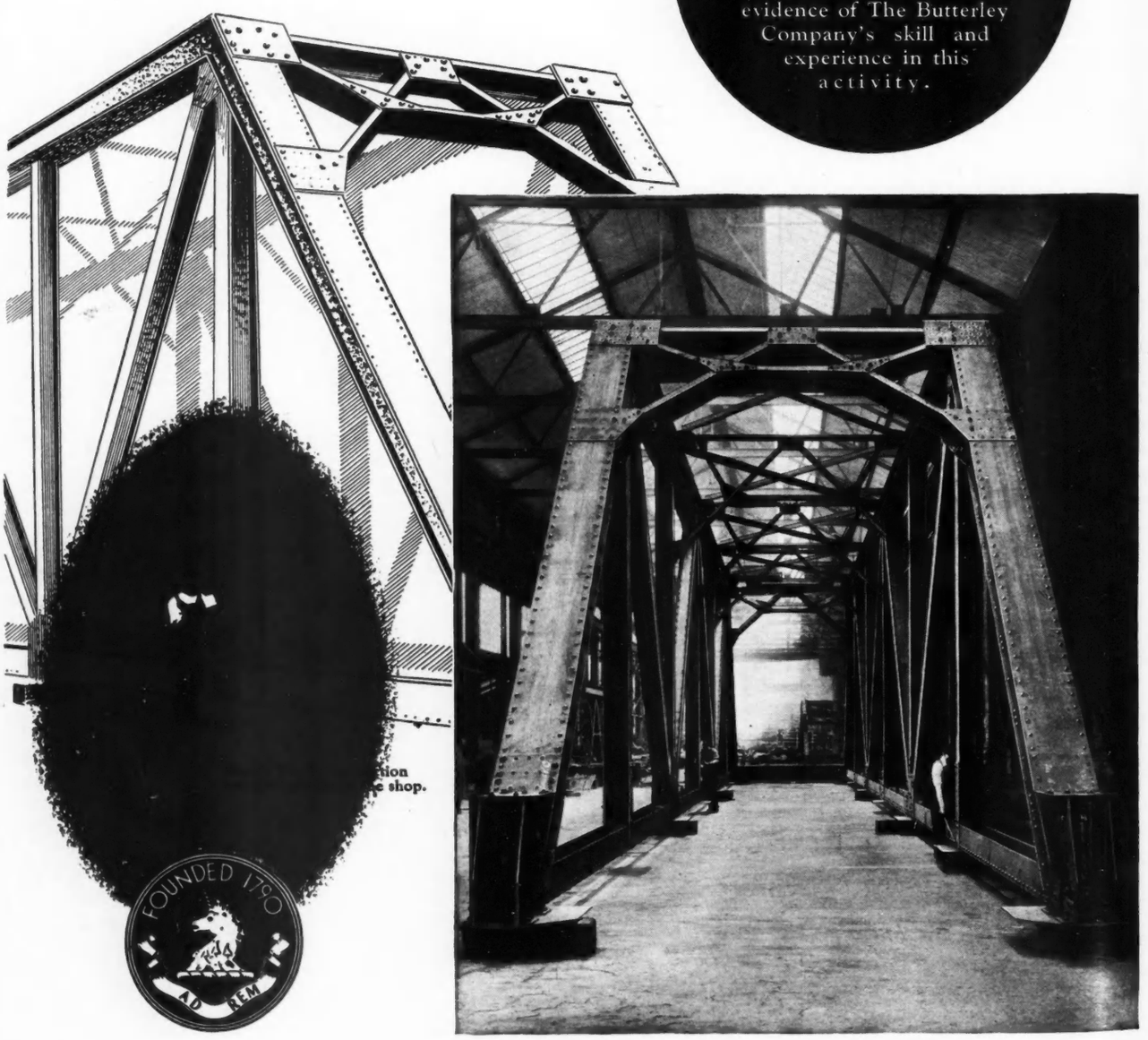


BLANKING STATOR AND ROTOR LAMINATIONS

CONSTRUCTIONAL STEELWORK *by*

# BUTTERLEY

This bridge section, part of a recent contract, represents another example of constructional steelwork by Butterley. At home and overseas many different kinds of steel structures stand as evidence of The Butterley Company's skill and experience in this activity.



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## A LARGE ORGANISATION

IT is generally believed that there are serious disadvantages in working for a very large organisation. The atmosphere lacks a personal touch; each man is just a cog in the machine; promotion is tediously slow—so the arguments run. The complaint is true of some large organisations but it can hardly apply to all, because there are some—maybe only a few—which do appear to encourage initiative.

Before the war the London Midland and Scottish Railway Company claimed to be the largest commercial undertaking in the world. To-day the British Transport Commission control an organisation which must be equal in size to at least three or four L.M.S. railway companies. As a result of experience gained during the past seven years, and of political forces in Parliament, the Commission have modified their organisation from time to time. They have now prepared a new system to take the place of the interim arrangement which has been in force since October, 1953, when the Railway Executive was abolished. There are only about 400 chartered civil, mechanical and electrical engineers in the national transport system (a surprisingly small number in relation to the range of engineering functions), but many engineering firms do business with one or more of the departments. Therefore the new system, which will be implemented on January 1, will be watched with interest by a large number of engineers.

The Commission continues to be "a policy-making body." The six regions of British Railways will be controlled by corresponding Area Boards. These Boards will be responsible to the Commission for the management of British Railways except for certain matters reserved to the Commission, such as the design, manufacture and standards of maintenance of locomotives, rolling stock, permanent way and signalling. At present they will be responsible only for their respective regions, but at some time in the future their responsibilities may cover other forms of transport in addition to the railways. The London Transport Executive will continue to be answerable directly to the Commission. There will be six Divisions covering British Railways, Road Services, Road Passenger Companies, Hotels and Catering Services, Transport Docks, and Transport Waterways, the two latter being separate instead of the present one organisation.

This is the general arrangement. It is, however, the Commission's headquarters organisation which is the most vital part of the new arrangements, since the headquarters staff will have it in their power to inspire the whole transport system or, if the organisation is not the most appropriate, to retard and frustrate. The members of the Commission will form various committees and "sub-commissions." The committees will deal with finance, establishment and staff, technical development and research, works and equipment, and so forth; the sub-commissions will each devote special attention to one of the Commission's activities, for example, railways, road haulage, London Transport, etc. The Commission will have the assistance of two advisory bodies—the Research Advisory Council and the British Transport Joint Consultative Council, both of which will have, as at present, distinguished representatives from outside the organisation.

A "general staff" will cover the activities of the whole of the Commission's undertaking. General Sir Daril Watson will be the Secretary General of this staff, and the senior members will include a technical adviser (to which post Mr. J. Ratter, C.B.E., has been appointed), and a supplies and production adviser (a post which has still to be filled). The staff of the Railways Division will include a chief mechanical engineer (Mr. R. C. Bond), a chief electrical engineer (Mr. S. B. Warder), a chief civil engineer (to be appointed), and a director of research (Mr. T. M. Herbert).

It may be questioned whether such a headquarters organisation is best adapted to its policy-making function. Indeed, the official statement refers more particularly to matters requiring a decision which emanate from lower down in the organisational scale rather than to the initiation of policy at Commission level. Thus it is stated that the general staff will "channel all communications from the Areas, London Transport . . . to the appropriate Committee or Sub-Commission." It is significant that the Unilever organisation, to which General Watson referred when he was explaining the new system at a Press conference earlier this week, includes advisory and service departments dealing with buying, economics and statistics, information, marketing, civil defence, and production study in the U.K. headquarters. For a policy-making body controlling a vast organisation, information, market research and similar branches are vital if it is to give a lead. There is nothing quite like this in the Commission's system; even the list of Central Services of the Commission starts with "archives" and ends with "historical relics," with in between such branches as police, legal services, paper and printing. The new system bears too much resemblance to an over-grown railway company. Like a large commercial organisation, it should have been designed to give direction and inspiration to a great service.

# Weekly Survey

## END OF THE ROAD FUND

Last week saw not only an undertaking in the Queen's Speech to increase the amount of money to be spent on the roads, but also the formal decision to abolish the Road Fund. There is a certain paradoxical flavour in a situation where the priority of the much neglected road system is moved up several places on the list of national capital development projects and where the original instrument for ensuring the development of the roads is brought to an end.

Originally the Road Fund was set up as a means of accumulating taxation on vehicles and fuel to be used for development of the roads. Successive Chancellors of the Exchequer, however, found the Road Fund too tempting a source of revenue to be used exclusively on the roads and it was repeatedly raided for other purposes until it eventually ceased to be anything more than a name. The Treasury has now formally killed it off, and from now on public money spent by the central Government on roads will be taken from the vote of the Ministry of Transport. Legislation to effect these changes will be introduced in due course.

From the ashes of the Road Fund arises, however, the Government decision to spend somewhere between two and three times as much a year on the roads as at present. The existing programme is for a three-year plan involving an expenditure of £50 millions in addition to local authority expenditure. The new scheme announced in the Queen's Speech must therefore be for an annual programme of road building of between £30 and £45 millions. The exact figure is not yet known, nor are details yet available of the way in which the figure might be affected by Local Government expenditure.

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## TINPLATE CONTAINERS

The announcement by the Metal Box Company last week that they would maintain the interim dividend at last year's level of 5 per cent. on an increased capital was accompanied by a short review of the company's progress during the six months ending September 30. There has been a substantial expansion of turnover: home sales were 23 per cent. greater than in the corresponding period of 1953, and export sales 16 per cent. greater. This is in line with the trend of expansion by the packaging industry since the war, although in the past year the rate of expansion has probably been greater in the case of tinplate containers than other types. There is, however, a rising demand for all forms of packaging, due to increased sales of food, cosmetics and pharmaceuticals. The end of rationing, which led to a rise in the sale of most foods, also led to a considerable increase in competition, placing a premium on attractive packaging. The output of printed tinplate containers, for example, increased and is still increasing. The growth of self-service stores is another factor in the rising demand for tinplate containers, and the output of the Metal Box Company is likely to be higher during the second half of their financial year (ending March 31) than during the first half. It may be, however, that the supplies of tinplate will once again become a limiting factor.

Output of " tin, terne and black plate " during the first seven months of this year was about 20 per cent. higher than in the corresponding period of 1953, but allocations to the food-canning industry are said to be lower. Last October a deputation from the food-manufacturing industry went to the Ministry of Food to express concern about the quantity and quality of tinplate allocated to the industry during the fourth quarter (Weekly Survey, October 22). The allocation was said to have been cut to about 70,000 tons compared with an average of 75,000 tons for the first three-quarters of the year. The shortage is said to be mainly due to an increase in export demand which followed reductions in export prices, and also to a shortage of labour which makes difficult the re-opening of old hand mills shut down last year. The solution is likely to be found by increasing imports of American tinplate until the Steel Company of Wales open their new continuous strip mill at Velindre in 2½ years time.

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## HIGHER STEEL PRICES

New maximum prices for iron and steel products which have come into effect on December 6 represent a general increase of about 1 per cent. on the level of prices in operation before that date. The changes announced last week are a final step in the review of prices and profit margins which the Iron and Steel Board has been making during the current year. Tentative price adjustments were made for pig iron in March of this year and for a wider range of products in May. These increments brought about an average increase in iron and steel prices of 2 per cent., so the further 1 per cent. effected by the changes this week makes a total increase in prices of about 3 per cent. It has been decided to raise the maximum price of the better classes of iron and steel scrap as from the same date in order to encourage the improved preparation and selection of scrap.

There is some deviation from the average in particular cases. Basic pig iron is increased by 5*s.* a ton and hematite pig iron by 8*s.* a ton, representing price increases of 1·6 and 2·3 per cent. respectively. Forge pig iron and foundry pig iron, No. 3, class 2, have gone up by 4·3 per cent. Among steel prices a number have been reduced, such as billets for re-rolling, billets for forging, soft basic, wire rods (non-alloy, soft basic) and certain re-rolled steel products. Boiler plates are up by 3·5 per cent., heavy rails by 1·7 per cent. and bright non-alloy bars by 3·2 per cent. The price of the basis qualities and sizes of many steel products have not been changed, including plates, heavy sections, tubes and tinplate. One interesting new departure in pricing practice is the introduction of zone extras for billets. These have been introduced " to reflect in a broad way" additional costs of delivery to distant areas from the main billet-producing centres. These products will thus come into line with other steel products where it is recognised that customers near steelworks have an advantage over more distant competitors. Increases in price have also been made in the extras permitted for special qualities and sizes, and the price structure for strip mill sheets has been changed to make the basis that of wide strip in coil form, thus bringing the price basis into line with modern production usage.

The Council of Ironfoundry Associations has already registered its disapproval of any general increase in scrap prices. They are particularly concerned at the increase in the price of steel scrap to ironfounders. Price increases are never welcome to user industries and they are particularly unwelcome from basic industries which have spent large sums on modernisation. Steel, however, has had to absorb increases in its raw-material prices which have offset some of the economies resulting from modernisation.

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## CATHODIC PROTECTION

A joint committee for the co-ordination of the cathodic protection of buried structures has been formed, membership of which has been confined to representatives of organisations or industries responsible for buried structures through ownership or otherwise. At present, the organisations represented comprise the British Electricity Authority, the British Transport Commission, the Gas Council, the General Post Office, United Kingdom Pipelines, and the Water Research Association.

Evidence of the increasing use of the cathodic protection method in this country is provided by the fact that, although the records are not yet complete, information has already been received regarding some 200 installations which are either in operation or are projected. Installations by impressed current or reactive anodes are in use for the protection of water, gas, oil and sewage pipes, telephone and electricity-supply cables, and structures such as oil tanks and jetties.

The need for co-ordination arises largely from the fact that current circulating in the soil from a cathodic-protection installation may accelerate the corrosion of nearby structures, and methods of assessing the probability of damage in particular cases are being studied. One method of preventing such harmful interaction is to extend the cathodic-protection installation to cover neighbouring structures by connecting them to the protected structure, with suitable safeguards where necessary, either directly or through resistors or other devices. It is, therefore, necessary to consider the conditions under which such interconnection of buried structures is permissible.

As, ultimately, it will be necessary to make the findings of the joint committee generally available in the form of a Code of Practice, a technical panel has been set up. The terms of reference of the panel are " to study cathodic protection with a view to the eventual drafting of a Code of Practice, with special reference to the possibility of cathodically-protected systems endangering adjacent buried structures, and to joint protection schemes." The membership of the panel consists of one representative from each of the organisations comprising the joint committee, together with Dr. F. Wormwell, representing the Department of Scientific and Industrial Research, who is chairman of the panel. Arrangements have also been made to ensure liaison with the British Cast Iron Research Association, the British Electrical and Allied Industries Research Association, the British Iron and Steel Research Association and the British Non-Ferrous Metals Research Association.

The secretary to the joint committee is Mr. J. H. Gosden, British Electricity Authority, Chief Engineer's Department, Bankside House, Sumner-street, London, S.E.1.

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## PRESSURISED CIVIL AIRCRAFT

The recent decision of the Air Registration Board to call for repeated loading tests on an entire aircraft of any new civil type, with the cabin subjected to pressure cycles in a water tank as carried out at Farnborough on the Comet, has raised some interesting queries. One which will probably occur to many passengers relates to pressure-cabin aircraft already in service: what is the risk of fatigue failure in these?

A point which may not be generally appreciated is that the Comet is not the only aircraft in which fatigue cracks have been found in the pressurised fuselage. Serious cracks have occurred in the cabin of a well-known American civil airliner on more than one occasion, but since the machine concerned operates at medium altitudes only, i.e., at a moderate pressure difference, the cracks did not propagate catastrophically. This particular type of aircraft is not at present licensed for service by any British airline. As regards existing British pressurised air-liners, a Viscount fuselage is to be fatigue-tested by Vickers-Armstrongs Limited, and it is believed that one of the older Ambassador aircraft will be tested at Farnborough.

In the case of American aircraft—Stratocruisers, Constallations and Argonauts—at present in service with United Kingdom airlines, their total elapsed flying hours are so much lower than those of their counterparts in the United States, which have not yet given evidence of fatigue failure, that it is likely that the operators and the Air Registration Board will be satisfied as to their safety. If, however, British airlines propose to adopt new types of American aircraft, and particularly those designed for high-altitude operation, the Air Registration Board will probably not accept the certification of the

American Civil Aeronautics Administration if the repeated loading is not adopted as a requirement by that body.

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## ENGINEERS AND FARMERS

Farmers have derived considerable help from engineers, though not, perhaps, as much as they might have done. At the Smithfield Show which has been held at Earls Court this week, the products of both have been on show.

The total output of tractors and agricultural machinery is running at well over £100 million a year. During the first six months of 1954, production increased by over £8·5 million compared with the same period of 1953, and more than half the total goes to markets overseas, much of it to British Dominions and Colonies. The demand is generally for well-known and tried equipment, but the makers of agricultural machinery are constantly improving existing machines and experimenting with new designs. By the nature of the work it is generally a long time before a new idea can be tested in the field and modified until it is ready to be put into general production. There is, for example, only a limited season for potato harvesting and hop-picking, and new machines for these jobs can be tried out in the field during only a few weeks in the year. Progress must be steady rather than spectacular; it is rare to find an agricultural machine in use one year that was not at least in embryo the year before. Since the war the principal developments have been the tractor with integrally-mounted equipment and the use in Great Britain of the combine harvester with its associated corn-drying equipment, and work is continuing along those lines. The main aim at present is to make any plant or machine work as much of the year as possible. Experiments have continued in the use of grain dryers for grass drying, thus keeping the plant in use for two or three months more each year. To produce more from his land is the aim of every farmer. Some of the machines exhibited at the Smithfield show which are helping to do this will be described in subsequent issues.

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## THE CEMENTATION COMPANY

In the past few years the Cementation Company, Limited, have not found it easy to cope with the growing demand for their services. Since this is likely to increase at an even faster rate in future, it is not surprising that the company are proposing to raise their present issued capital of £1·55 million by £750,000. At home, the large shaft-sinking programme in the developing coalfields alone puts a heavy strain upon their resources. This has given an opportunity to German contractors, whose employment by the National Coal Board for sinking a shaft in Wales has attracted much publicity—usually extolling the German approach to the work. In his statement issued with the accounts for the current financial year, however, the chairman, Mr. A. R. Neelands, assures stockholders that there is nothing to indicate any superiority in the German methods or performance over the British.

The overseas work of the Cementation Company has been varied and with few exceptions profitable, although there is always a fair element of risk due to many unpredictable factors, including the weather. The overseas work ranges from a contract for high-pressure cementation at the uranium mine at El Dorado, in Canada, to undersea geophysical work in the Persian Gulf in collaboration with Captain Cousteau, the undersea expert, and the French Government ship Calypso. Other work in the Near East includes a cementation contract using the Colcrete process " which will rival in value and importance the very similar work carried out at Camarasa in Spain many years ago."

Because of variations in the volume and type of work undertaken, flexibility is an important virtue in a firm such as the Cementation Company. From the point of view of the National Coal Board, for example, it is desirable that shaft-sinking programmes—for which contractors require very heavy capital resources—should be concentrated in as short a period as possible. When completed it may be quite a long time before the need for such work again arises. In the Orange Free State and in the Rand, the large shaft-sinking programmes of the past few years have now diminished. Fortunately the Cementation Co. (Africa) Pty., Limited, have found that with the expansion in mining, turnover has increased even more, due to a large volume of work in connection with water control.

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## MECHANICAL GARDENING

A branch of engineering which receives little publicity but which has been going from strength to strength is the manufacture of mechanical garden equipment. Particularly prosperous have been manufacturers of one of the oldest power-driven garden tools, the motor lawnmower (the first went into production in 1902). One of the leading manufacturers, Chas. H. Pugh Limited, report that their production programme in the past year " big though it was " fell short of demand and left them in a " sold out " condition for some of their popular models. Output statistics confirm that sales of lawnmowers have been remarkable. Monthly average deliveries in the second quarter of 1954 amounted of £663,000, which is half as much again as in the corresponding quarter of 1953. Sales in the Southern Hemisphere compensate for the fall in home sales during the winter months. In the first quarter of 1954, lawnmowers to the value of £242,000 a month were being exported out of total deliveries of £516,000.

The variety of garden tools and appliances has been increasing almost as rapidly as labour-saving household gadgets. In addition to mowers, which may be electrically or motor driven and capable of cutting long as well as short grass, the power tools available include a wide range of mechanical hoes and hedge cutters. Public authorities responsible for the maintenance of parks and playgrounds, private sports clubs, etc., faced with rising labour costs, naturally account for a high proportion of the market. Sales to suburban gardeners are large and increasing; there may be even more scope if designs of tools can be evolved which will lower first costs to a minimum.

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## STRESS CORROSION CRACKING

Arising out of a recent survey of 67 gasworks installations where stress-corrosion cracking had been reported, a committee of the British Welding Research Association, although still awaiting the final analysis of the reports, believe that certain conclusions are justified:

(1) Stress-corrosion cracking is not limited to welded gas mains; it appears, though less frequently, in welded vessels.

(2) Its appearance has been found to be not related to any group of coals or any types of carbonising plant. No cases connected with water gas are known, and producer gas is not seriously suspected.

(3) The range of expected occurrence is now extended to include the foul main and to terminate at the outlet of the final ammonia washers.

(4) Stress relief, by heat treatment, to a not unduly exacting specification, is apparently able to prevent its appearance entirely, and probably also to meet the effects of added strains such as arise from mechanical vibration, ground movement, etc., if these are not excessive. Shot-peening has not been tested with equal thoroughness.

(5) Previously stress-relieved work should not be re-welded for alterations without afterwards restoring the stress relief.

(6) High quality of welding does not confer immunity, and there are some doubts in regard to riveted work being completely resistant.

The interim report conveying these conclusions has been circulated to the authorities directly interested in the manufacture of coke and gas.

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## NORTHERN EUROPE

A recent report on economic conditions in Denmark, Iceland and Norway prepared by the Organisation for European Economic Co-operation is of some significance to the British engineering industry. Denmark has been passing through a period of moderate recession from which it is now emerging, but its external trade balance is still causing some concern. A large programme of imported feeding stuffs has increased the import bill and this is expected to remain at a high level for some time yet. It is hoped to offset the high level of imports by increased exports and Danish opinion seems to favour the expansion of engineering exports. Obstacles in the way of achieving this at the moment are the comparatively high level of labour costs in the Danish labour industry and shortage of finance. There seems to be some suggestion, however, that the Government might help in the second of these problems by discouraging the upward trend of private consumption in the Danish home market. O.E.E.C. itself is inclined to put less emphasis on Denmark's need to export capital goods and thinks that the recovery in Western Europe may bring with it an increased outlet for Denmark's agricultural exports despite the tariff barriers and quota restrictions which exist in many markets.

In the case of Norway the interest for the British engineering industry in the country's future centres more on the outlook for British goods in the Norwegian market. It seems likely that rather less of the country's resources will be devoted to capital investment in the immediate future than has occurred since the war. For example, aggregate gross capital formation (which includes both the installation of new equipment and provision for depreciation of capital goods already installed) and inventories are expected to take 29 per cent. of the gross national product per annum in 1955 and 1956—compared with 31 per cent. this year. It is expected that the main impact of the fall will be on the merchant fleet and general engineering equipment. Norway expects as well, however, to increase its exports and is relying on the output from its expanding electro-metallurgical and electro-chemical industries to bring this about.

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## AIRCRAFT INDUSTRY IN CANADA

Since the end of the second World War, there has been a rapid expansion of Canadian industry. One of the most notable examples is the growth of A. V. Roe, Canada, Limited, which, as announced elsewhere in this issue, has been reorganised into three subsidiary companies: Avro Aircraft, Limited, with 10,000 employees; Orenda Engines, Limited, with 6,000 employees; and Canadian Steel Improvement, Limited, with 400 employees. When A. V. Roe, Canada, Limited, was first formed in 1945, by the Hawker Siddeley Group, the total manufacturing area occupied one million square feet. To-day, it is nearly three times that area, mainly concentrated at Malton, Ontario, and includes one of the best-equipped manufacturing plants for gas-turbine engines in the world.

In addition to the development contract placed by the Canadian Government for the C.105 twin-engine supersonic long-range all-weather fighter aircraft " of advanced design " announced by the Avro Canada Group, they are developing privately a new engine which " is expected to open up new fields of jet power " and in which titanium will be widely used.

It is believed that this engine is a twin-spool turbojet developing about three times the thrust of the Orenda engine, and is expected to commence running early next year.

# ENGINEERING GOODS IN THE COLONIES

## 2—STUDYING LOCAL CONDITIONS

In the first of these two articles emphasis was laid on the large expansion in exports of engineering goods from the United Kingdom to the Colonies since the war, an expansion which is likely to be at least maintained over the next few years. It is therefore reasonable to look upon the Colonies as a market worth systematic investigation; they offer scope and stability in marked contrast to their prospects as a market before the war.

### WHAT DO THEY SPEND?

An estimate of the market potential of these areas is not easy to compute. It is the sum total of the prospects for individual products in several dozen markets each of which differs radically from the others in many important respects. Nevertheless it is possible to obtain some idea of the scope of the market by looking at a few global figures. It was estimated in a Colonial White Paper at the end of 1951, that the value of capital works in hand in the Colonies was £250 million. This figure did not cover all private enterprise. It is probable, therefore, that £300 million would be nearer the mark in round figures. Of this, about £150 million arose from initial grants under the Colonial Development and Welfare Acts, which were at that time represented by work in hand of £78 million. By March, 1954, the work in hand under the Colonial Development and Welfare Acts was about £120 million, and it is probable that the overall commitments for capital works in the Colonies had moved up in proportion to the increase from £78 million to £120 million. This would make the corresponding total commitments for capital works in the Colonies at March, 1954, to be £460 million. Most capital works take about two years to build but some of this £460 million represents 8 and 10 years development schemes. The average is therefore likely to be nearer four years. The annual value of commitments was therefore probably running in 1954, at about £115 million. The prospective annual rate of commitment for officially sponsored schemes and for private enterprise developments might therefore be taken at, say, £150 million a year in the next few years.

The estimate made from official sources in 1951, split up the capital commitments of £150 million as follows:

24 per cent. for electric power;
23 per cent. for transport;
22 per cent. for building;
15 per cent. for waterworks;
16 per cent. for miscellaneous.

These figures, however, represent only the shells of factories and other installations. They do not include plant and equipment and, of course, there is no figure for the wide range of engineering goods such as vehicles which require no factory space to operate, only maintenance services. It is therefore probable that the annual rate of investment in engineering goods in the Colonies—taking the word investment in its widest sense to include such consumer durable goods as motor-cars—is in the region of £300 million a year. It would appear, taking into account the figures published in the Tables last week, that this annual investment programme of £300 million is being accompanied by the importation of some £150 million a year of engineering goods, of which about £100 million comes from the United Kingdom. As a rough guide to the export potential of the Colonies, it can thus be said that the value of annual trade in engineering goods to such areas is about one-third of their annual capital investment programme.

From the foregoing figures based on the 1951 capital investment analysis, about half the annual investment of £300 million is officially sponsored. Much of this is again related to long-term development programmes under the Colonial Development and Welfare Act passed by the U.K. Parliament. This Act is now considered by both political parties in this country to be a long-term feature of British colonial policy. Again, the balance of the £150 million not covered by the C.D. & W. Act is backed by good fiscal reserves in colonial exchequers. It can thus be inferred that only the second £150 million is likely to be affected seriously inside ten years or so by changing economic conditions in the Colonies. It was argued in the previous article, however, that these conditions were not likely to change seriously for the worse in the foreseeable future.

Working forward again from the official figures given in 1951, it is probable that the capital investment programmes in the main colonial areas at the present time are running at about the following levels per annum: British West Indies £34 million, East Africa £54 million, West Africa £46 million, Central Africa £36 million, Malaya £97 million, remainder £33 million.

### BRITISH FIRMS

These statistics indicate a level of capital investment which is bound to bring about a gradual, though noticeable, increase in the national income in these areas, which should lead to an expansion in the home market in each case. This means that British engineering concerns may look forward to increased sales from three sources. These are: ground gained from other countries exporting to these areas where prices are competitive enough; increased local demand arising from buoyant exports; and an expansion in the same demand owing to the growth of the local domestic market. The probability is that in many cases the rate of expansion will be slow because the increase in exports and the advance in the rate of capital investment will be slow. This conclusion, however, might well prove pessimistic. For example, the development in the Gold Coast of the new alumina and hydro-electric scheme will cost £144 million. Much of this will be represented by materials and equipment for which British companies will have an opportunity to tender, and while this vast scheme is under construction the level of imports into the Gold Coast must at least temporarily exceed the level of recent years. Another case might arise in Malaya, where the pilot schemes being undertaken to find out if rice can be developed in new areas might result in an expansion programme for rice cultivation which would cost several million pounds. This could lead to a large demand for British equipment to drain and plough, by mechanised means, a vast area of virgin jungle swamp.

The outstanding feature of the Colonial market is its diversity and the need to study local conditions. Broad generalisations on what the West Indies will take compared with Central Africa have one use only, and that is to indicate the broad outlines of the marketing problem. The vast flow of literature from official and unofficial sources in recent years reiterates the need for salesmen to study the local market, its climatic peculiarities, the variations in soil and road conditions, the quality of the labour, the length of the ploughing and growing seasons in the case of agricultural machinery, the heavy burden of transport costs in the siting of factories, the quality of management and the dearth of technical "know-how." Many companies are slow to learn the vital importance of spare parts and after-sales service, a matter which is just as important in such areas as in highly industrialised overseas communities.

The broad generalisations are, however, worth repeating if only to show the diversity of the problems which await companies that plan to develop their colonial markets. In the West Indies the critical factor is the strength of American competition and the tendency for many industrialists to look north for their technical assistance rather than east across the Atlantic. It is, of course, likely that the country which supplies the consultants and technicians will eventually supply the engineering equipment.

### PROMISE OF AFRICA AND MALAYA

In East Africa and Central Africa the features are the large size of the development programmes which have been initiated of recent years, the increased facilities for economic development which the creation of the Central African Federation and the looser East African Customs union have brought, and the goodwill for British equipment which exists with the white population. It is interesting to note in this context that despite the large volume of literature which has been published in recent years on the scope for mechanisation of East African non-native agriculture, few companies in this country seem to have taken advantage of it and to have developed this market at all systematically.

In West Africa the features are the growing wealth of the African community, the nascent nationalism of Nigeria and the Gold Coast which are moving towards some form of Dominion status, the big opportunities which exist for large capital development schemes and the probability that in complete contrast to these large schemes the agricultural and industrial economy will move forward only as methods of peasant cultivation can be improved. The danger in this area is that a superficial examination of market prospects will concentrate too much on mechanisation and industrialisation as illustrated by, say, the Volta River project, important as this scheme undoubtedly is. In Malaya, there still exists the problem of political unrest which overshadows the development of the economy. The fact remains, however, that Malaya has probably the highest rate of industrial investment of all colonial areas at this moment and it is, incidentally, one of the largest markets for U.K. cars in the Commonwealth. In recent years it has taken three-fifths as many cars as the Dominion of South Africa. Here is one more instance of the need to examine local conditions and not to accept superficial generalisations about market prospects in the Colonies.

To sum up: the colonial territories, which have a much more stable record since the war as earners of hard currency than either the United Kingdom or the Dominions, offer continued openings for engineering goods for those who will take the trouble to examine and cater for local requirements. The most promising areas are Malaya, East Africa, West Africa and Central Africa. The propinquity of the three African territories to one another in the Air Age and the possibility of developing all three of them according to some coherent pattern will not be lost on those who study a map before they enter a new territory. Those who do study the map may come to the conclusion that the opening up of the Dark Continent has only just begun.

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## AN ELECTRICAL DIPLOMA SCHEME

To encourage the education and training of technicians in the electrical industry the Association of Supervising Electrical Engineers has instituted a Technicians Certificate, in addition to the Swann Diploma. The grant of this certificate will depend on the result of an examination, the syllabus of which will include written and oral questions on basic principles and general applications. The examination for the Swann Diploma is also to be extended. A brochure giving full details of both examinations can be obtained from the secretary of the Association, 23 Bloomsbury-square, London, W.C.

## PERSONAL

SIR STEPHEN TALLENTS, K.C.M.G., C.B., C.B.E., has been elected President of the Design and Industries Association, 13 Suffolk-street, Haymarket, London, S.W.1, in succession to SIR COLIN ANDERSON.

MR. J. S. PICKLES, B.Sc., M.I.E.E., is to be chairman of the new South of Scotland Electricity Board, set up under the Electricity Reorganisation (Scotland) Act, 1954. SIR NORMAN DUKE, K.B.E., C.B., D.S.O., M.C., is to be deputy chairman, and MR. WILLIAM HUTTON, M.A., LL.B., Comp.I.E.E., and MR. W. S. SAWTELL, M.I.E.E., full-time members. Five part-time members have been appointed, namely, COLONEL J. G. CRABBE, O.B.E., M.C., SIR JOHN IMRIE, C.B.E., M.A., B.Com., MR. JACKSON MILLER, C.B.E., D.L., BAILIE JOHN SULLIVAN and SIR RONALD J. THOMSON.

MR. G. BURDON, B.Sc., principal officer, Marine Survey, Glasgow, has been appointed deputy Engineer Surveyor-in-Chief, Marine Survey Service, Ministry of Transport and Civil Aviation, with effect from February 12, 1955. He succeeds MR. F. J. WELCH, whose appointment as Engineer Surveyor-in-Chief, as from the same date, was announced on page 684 of our issue of November 26.

DR. A. G. TOUCH has been appointed director of electronics research and development, Ministry of Supply, in succession to AIR COMMODORE W. G. PRETTY. AIR COMMODORE C. A. BELL will succeed Dr. Touch as deputy director, electronics research and development (air).

MR. F. J. MAYOR, M.I.Mar.E., A.M.I.Mech.E., has been nominated to serve as President of the Diesel Engine Users Association during 1955.

MR. H. F. SPENCER has been appointed chairman of the British Institute of Management, Management House, 8 Hill-street, London, W.1, in succession to SIR HUGH BEAVER, who retired from that office on December 1.

MR. H. E. SNOW, C.B.E., has resigned from the board of the Anglo-Iranian Oil Co., Ltd., on taking up the appointment of general manager of Iranian Oil Participants Ltd.

CAPTAIN (E) L. F. INGRAM, R.N., has left his appointment as Fleet Engineer Officer, Submarines, and is now in charge of the R.N. Mechanical Training and Repair Establishment, Flathouse-road, Portsmouth, Hampshire.

MR. A. H. FROST, southern area manager of Constable, Hart & Co. Ltd., Lion House, Richmond, Surrey, has been elected a director of the company.

MR. H. C. ORCHARD, A.M.I.C.E., acting assistant engineer (permanent way), Eastern Region, British Railways, has been appointed assistant civil engineer, Scottish Region, with effect from November 29.

MR. W. T. MATTOCK, M.Inst.Gas E., has been appointed chairman of William Sugg & Co. Ltd., gas engineers, Westminster, London, S.W.1, in succession to MR. PHILIP SUGG.

MR. J. D. CAMERON, M.I.Mar.E., superintending engineer, Orient Steam Navigation Co. Ltd., 7 and 11 Bishopsgate, London, E.C.2, retired on November 30 after 45 years of service with the company. Mr. Cameron has been succeeded by his assistant, MR. H. KNIGHT.

MR. J. C. MORRIS, B.Sc., A.M.I.C.E., chairman of the Council of the Royal Sanitary Institute, 90 Buckingham Palace-road, London, S.W.1, and Borough Engineer and Surveyor, Willesden, is to represent the Institute on the Regional Advisory Council for Higher Technological Education, in place of the late MR. REES J. WILLIAMS.

DR. A. J. HAYTER, formerly head of the processes projects initiation department of Head, Wrightson & Co. Ltd., has now taken up an appointment with Messrs. Sharples Process Engineers Ltd., whose London office has recently been moved to Brookfield House, 62 Brook-street, W.1.

MR. A. S. LADLEY has been elected chairman and MR. J. C. Y. BAKER and MR. J. E. GRAY vice-chairmen of the Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1.

MR. G. G. ROBERTS, B.Sc.(Wales), M.Sc.(Lon.), has now taken up his duties as technical executive officer in charge of the guided-weapon activities of Smiths Aircraft Instruments Ltd., at Cheltenham.

MR. F. Q. DEN HOLLANDER, President of the Netherlands Railways, has accepted an invitation to become a member of the technical development and research committee of the British Transport Commission.

MR. C. W. KENYON, A.M.I.Mech.E., sales manager, stoker department, Stockport, of the Mirrlees Watson Co. Ltd., Scotland-street, Glasgow, C.5, is retiring after 51 years of service with the firm.

## BUSINESS CHANGES

The HAWKER SIDDELEY GROUP have created a subsidiary but parallel group organisation in Canada. Under this A. V. ROE CANADA LTD. is to be the parent company in the Dominion with three operating but independent subsidiary companies, namely, AVRO AIRCRAFT LTD., ORENDA ENGINES, LTD., and CANADIAN STEEL IMPROVEMENT LTD. SIR ROY H. DOBSON, C.B.E., F.R.Ae.S., head of A. V. Roe & Co. Ltd., Manchester, is to be chairman of the new group, and serving with him on the board of A. V. Roe Canada Ltd., are SIR FRANK SPRIGGS and SIR THOMAS SOPWITH, C.B.E. MR. CRAWFORD GORDON, JR., another director, has been appointed President and general manager. The heads of the three operating companies are: Avro Aircraft Ltd., MR. F. T. SMYE; Orenda Engines, Ltd., MR. W. R. MCLACHLAN; and Canadian Steel Improvement Ltd., MR. C. J. LUBY.

THE BRUSH GROUP LTD. have arranged for their subsidiary company, ASSOCIATED TUBE WELLS LTD., to sell to an Indian industrialist their tube-well trading assets. Associated Tube Wells will now confine themselves to the provision of power houses, etc., which are in the normal course of the Group's business.

GRIMSTON ASTOR LTD., Bideford, North Devon, are shortly to change their name to UNIVERSAL LAUNCHES LTD. The directors, management, policy and staff of the company will remain unaffected by the change.

SIR W. H. BAILEY & CO. LTD., Albion Works, Patricroft, Lancashire, opened a London sales depot at 4 Domingo-street, Clerkenwell, E.C.1 (Telephone: CLErkenwell 0791-2) on December 1. On the same date the firm's London office was transferred to the new address from Dartmouth-street, Victoria, S.W.1.

The new Newcastle-upon-Tyne branch office of the JOHN THOMPSON GROUP OF COMPANIES, at "Ravenswood," Westfield-lane, Ryton-on-Tyne, Co. Durham, is to be managed by MR. S. A. H. ROBINSON.

MINE SAFETY APPLIANCES CO. LTD., Queenslie Industrial Estate, New Edinburgh-road, Glasgow, E.3, and THOMAS A. EDISON LTD., London, have jointly announced that the former company have purchased from the latter the miners' electric cap-lamp manufacturing facilities situated in Glasgow adjacent to their present plant. Other interests and operations of Thomas A. Edison Ltd. in Great Britain will not be affected by this change.

The address of the FLAME RADIATION RESEARCH BRITISH COMMITTEE has been changed to 6 De Veregardens, London, W.8 (Telephone: WEStern 0761).

ALFRED HERBERT LTD., Edgwick, Coventry, announce that their associate company, ALFRED HERBERT (AUSTRALASIA) PTY. LTD., established in 1919 with offices and showrooms at Pyrmont, Sydney, Australia, have now removed to new premises built on the corner of Booth and Taylor Streets, Annandale, Sydney.

HONEYWELL-BROWN LTD., have opened a new area office at 119-121 Albert-road, Middlesbrough.

ROTO-FINISH LTD., 39 Park-street, London, W.1, are building a new factory at Hemel Hempstead, the new satellite town, to centralise under one roof, the administration, laboratory and production department at present spread over three addresses.

GEM BRUSHES (LUSON) LTD., announce their recent acquisition of the KINGSWOOD MANUFACTURING CO. LTD., Letchworth, Hertfordshire.

HOUSEMAN AND THOMPSON LTD., a firm specialising in industrial water treatments, D.M. House, Jesmond-road, Newcastle-upon-Tyne, have taken over the selling and marketing, throughout the world, of Heron drum heaters.

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## OBITUARY

*We regret to record the deaths of:*

MR. GEORGE STANLEY RAMAGE, at his home in Alloa, Clackmannanshire, on November 19. He had been secretary of the Harland Engineering Co. Ltd., B.E.P. Works, Alloa, since 1923 and financial director since July 1, 1953.

PROFESSOR ARCHIBALD READ RICHARDSON, D.S.O., B.Sc., F.R.S., at his home at Sea Point, Cape Town, South Africa, recently. He was Professor Emeritus and, until his retirement in 1940, Professor of Mathematics at University College, Swansea. Previously he had served as assistant professor of mathematics, Imperial College of Science and Technology. In 1932 he was elected a Fellow of University College London, and, in 1946, was made an F.R.S., for his distinguished researches in algebra, including non-associative algebras, generalised determinants and groups characters.

MAJOR VIVIAN FORD GLOAG, M.C., at his home in Bayswater, on November 28, at the age of 65. He had completed 35 years of service with Simon-Carves Ltd., Cheadle Heath, Stockport. Major Gloag was in charge of the firm's chemical-plant department from 1920 until 1945 when he was made London director. He had been elected to the board in 1926. He became a member of the Institution of Chemical Engineers in 1924, served as a member of Council from 1944 until 1947 and was a vice-president from 1947 until 1949. For gallantry while serving with the Durham Light Infantry, during the war of 1914-18, he was awarded the Military Cross.

WILLIAM MILES HORSFALL, M.I.E.E., on December 1, at his home, Heath Lodge, Hooton, Wirral, at the age of 81. In his younger days Mr. Horsfall was for 13½ years engineer and manager of the Liverpool District Lighting Co., Ltd., after which he was for six years consulting engineer with Robinson & Horsfall, Liverpool. In 1935 Mr. Horsfall retired from the position of sales engineer to the Edison Swan Electric Co. Ltd., owing to ill health.

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## *Letters to the Editor*

### APPROXIMATIONS FOR SEC θ

#### Rationalising Strut Formulæ

SIR, It is very pleasing to note that the article by my mathematical colleagues, Dr. T. A. S. Jackson, Professor L. Rosenhead, F.R.S., and Mr. T. Murphy, "Webb's Approximation of Sec $\theta$," (ENGINEERING, vol. 176, page 298, 1953) has been of interest to Mr. G. Pearson working in the Forest Products Division of the Australian Commonwealth Scientific and Industrial Research Organisation.

The illustration which Pearson gives in his own article, "The Secant Approximation and the Perry Formula: Expressions for eccentrically-loaded struts," published on page 594 of your issue of November 5, emphasises, as indeed the previous authors emphasised analytically in their article, that the closeness of the approximation to sec $\theta$ depends to a very large extent on the way the factor

$$\frac{1}{1-\left(\frac{2\theta}{\pi}\right)^2}$$

approaches infinity as $\theta$ approaches $\frac{\pi}{2}$, or, as in the corresponding expression,

$$\frac{1}{1-\frac{P}{P_e}}$$

the applied load P approaches the critical load $P_e$. This is just an analytical way of saying that the strains in the imperfect structure will tend to become very large as the load on the structure approaches that critical load which will hold a perfect structure deformed.

It is this physical factor which is responsible for the Perry-Robertson or Southwell-Smith formulæ giving, particularly for large values of the slenderness ratio, close approximations to the maximum loads which struts may carry. W. Merchant, in his paper, "The Buckling of Pin-Ended Struts under Axial Load," (*The Structural Engineer*, vol. 27, page 363, 1949), showed analytically, however, that for an idealised elasto-plastic material the maximum load which a strut can carry can also be written in the Perry-Robertson form, although the quantities involved had a different physical meaning. Merchant's approach removes the inadequacy of calculations based on maximum stresses to which Pearson refers in the last sentence of his article.

Yours faithfully,

J. B. B. OWEN,
Professor of Civil Engineering.
University of Liverpool,
November 27, 1954.

# OBTAINING GOOD CONCRETE

## *Review of Ministry of Works Experience*

During the past four years the Ministry of Works have been making a determined effort to improve the average quality of the concrete used on sites under their control. A brief review of the methods adopted, the economies in cement effected and the overall results of the work has been given in a note recently issued to the technical Press.

The form of the specification for concretes has been amended to cover the minimum strength of the concrete, freedom from surface defects and the water-tightness required; the mix is then designed to suit the aggregate available. In general, it has been found that the use of a guaranteed-strength type of specification, with mixes designed for workability and strength to suit the aggregate, and the use of vibrators to attain good compaction, can lead to a reduction in costs and to a definite improvement in the uniformity of the concrete.

The reduction in the proportion of cement used has varied from about 10 per cent. for hand-placed concretes designed for 3,000 lb. per square inch at 28 days to 40 per cent. in the case of a high-quality concrete which was to be prestressed. Reductions in cement content of 15 to 20 per cent. (¼ to 1 cwt. per cubic yard) have been common when vibration has been used to produce concrete with a minimum strength of 3,000 lb. per square inch at 28 days. Even for hand-compacted concrete of this quality it has been found necessary to use mixes of only 1 : 7½ by weight when the mix design is related to the aggregate.

In conjunction with the rational design of mixes, use has also been made of three techniques which have assisted in obtaining the improvements already outlined. They are: the use of a power float for surface finishing, the use of a vibrating roller for consolidating thin concrete slabs, and the early striking of shutterwork.

The power float has proved of great value when laying granolithic floors, allowing the use of a lower water/cement ratio and of fewer fines than hitherto, so giving rise to less laitance which causes dusting. Advantages have also been gained by placing the granolithic surface immediately after the base has been compacted, so ensuring a good bond which makes the surfacing an active part of the structural member.

### VIBRATING ROLLER

The poker type of vibrator is not well suited to the consolidation of thin concrete slabs and a more satisfactory machine has been found in the vibrating roller. This is able to give full compaction through slabs up to 8 in. thick of lean dry concretes with an aggregate-cement ratio of 16 : 1; cores from such slabs have been found to have crushing strengths of over 2,000 lb. per square inch at 28 days. With richer mixes (8 : 1) core strengths of more than 5,000 lb. per square inch have been obtained regularly, so making a general reduction in slab thickness possible.

With properly designed vibrated concrete it has been found possible to strip shutters about two hours after the concrete has been placed—unless there is a pronounced overhang. This practice has several advantages. The exposed surface can be readily treated while it is yet green, being smoothed with a steel float or the surface washed off with a fine spray to form a good key for plaster without the need for hacking. Joints, both vertical and horizontal, can be washed off, leaving the aggregate fully exposed, against which further concrete can be placed. Less damage is done to shutters during the operation of striking, and the shutters can be easily cleaned by washing. In those cases where the shutters can be used repeatedly, the amount of shuttering required for the whole job is considerably reduced by early striking.

# SMALL HEAT PUMPS*

## DOMESTIC APPLICATIONS IN GREAT BRITAIN

The electrical industry has been investigating the potentialities of the heat pump as part of its policy for fostering the use of electricity for all purposes where it can be used economically. The majority of the installations on which reports have been based have been in the United States of America or in Switzerland, and it is particularly unfortunate that the practical installation in this country (not electrically driven) which has received the most publicity was rendered practically useless by incorrect design information.

The performance energy ratios of 23 installations examined, ranging in size from 3 to 850 h.p., lay between 2·5 and 6·4, though one unit ran at between 15 and 20. If the performance is estimated from first principles the following conclusions are reached: (1) Owing to the fact that the Rankine rather than the Carnot cycle applies in practice, only 70 per cent. of the ideal performance can be achieved with known refrigerants. (2) With the best practical heat exchangers the efficiency of the evaporator and condenser can only be taken as 90 per cent. (3) Owing to the imperfection of adiabatic compression the efficiency of this part of the cycle is only 80 per cent. (4) The mechanical transmission may give a shaft efficiency of only 75 per cent.

In view of these losses, therefore, the actual energy ratio of the heat pump is unlikely to exceed the Carnot value multiplied by the product of these efficiencies, so that it is improbable that the ratio of output heat to input energy will in practice be much greater than half of $\frac{T_1}{T_1 - T_2}$. A practical comparison of the different costs of heating a large house are given in Table I below. Up to now, the heat pump has rather been penalised by high maintenance costs due to lack of experience. Apart from this, the initial cost would seem to be a limiting factor.

When, however, the pump is used for refrigerating as well as for heating, the plant becomes more economically possible. Consequently the adaptation of small refrigeration units for simultaneous heating and cooling domestic duties has been investigated and several machines produced. The successful production of hermetically sealed motor and compressor units made the absorption of a great deal of the waste heat possible, and in one American model the motor-compressor unit is inside a water jacket forming part of the hot-water tank with the evaporator and fan on top of the tank. No advantage is taken of the cooling produced by this machine.

If used properly and adequately insulated, the standing losses from a 30-gallon storage tank of hot water should not be more than 15 kWh per week. At 90 per cent. efficiency (obtainable with this degree of insulation) the heating of 350 gallons of water to 140 deg. F. requires 100 kWh of electricity in winter and about 90 in summer if an immersion heater is used. This is about 75 per cent. more hot water than is used by the average family of four living on local authority housing estates. A large electric refrigerator operating for 30 per cent. of the

* Extracts from "The Use of Heat Pumps of Small Capacity for Various Purposes in Great Britain," by Miss M. V. Griffith, B.Sc., F.Inst.P. of the Electrical Research Association, Greenford, Middlesex. Paper presented to the Institute of Refrigeration on November 25, 1954.

TABLE I.—Annual Cost of Heating a Large House Using 75,000,000 B.Th.U. Per Annum. Maximum Heat Load = 12 kW 41,000 B.Th.U per Hr.

| System | Solid Fuel | Fuel Oil | Gas | Electric Tubular Heaters | Electrode Boiler | Heat Pump | |
|---|---|---|---|---|---|---|---|
| | | | | | | P.E.R. = 3·0 (motor h.p. = 5·0 nominal) | P.E.R. = 4·5 (motor h.p. = 3·5 nominal) |
| Efficiency | 60 per cent. | 65 per cent. | 70 per cent. | 100 per cent. | 85 per cent. | | |
| Fuel price | £5 per ton | 1s. per gal. | 1s. 6d. per therm | 1d. per kWh | 1d. per kWh. | 1d. per kWh. | 1d. per kWh |
| Capital cost | £300 | £300 | £250 | £120 | £250 | £650 | £450 |
| Percentage capital charges | 10 | 10 | 10 | 7 | 10 | 10 | 10 |
| | £ | £ | £ | £ | £ | £ | £ |
| Fuel costs | 24 | 34 | 81 | 92 | 108 | 31 | 21 |
| Attendance | 40 | 15 | 5 | — | 10 | 5 | 5 |
| Maintenance | 7 | 5 | 3 | 3 | 5 | 5 | 5 |
| Annual capital charges | 30 | 30 | 25 | 8·5 | 25 | 65 | 45 |
| Total annual costs | £101 | £84 | £114 | £103·5 | £148 | £106 | £76 |

TABLE II.—Comparative Operating Costs for Dual-Purpose Heat Pump and Alternative Systems

| — | — | — | I | II | III |
|---|---|---|---|---|---|
| | | | Initial cost | Electricity Consumption per year (52 Weeks) | Cost at 1*d.* per kWh |
| | 1 | 4½ cub. ft. refrigerator (without purchase tax) | £77 | † 800 kWh | £3 6 8 |
| | 2 (*a*) | Electric immersion heater installed in existing tank | £20 | † 6,000 kWh for 350 gal. per week at 140 deg. F. and standing losses | £25 3 4 |
| | 2 (*b*) | Complete electric water-heating unit (without purchase tax) | £47 | Do. | £25 3 4 |
| A | | *Totals for*— 1 and 2 (*a*) or 1 and 2 (*b*) | £97<br>£124 | 6,800 kWh | £28 10 0 |
| B | 3 (*a*) | Dual-purpose heat pump driven by 0·25-h.p. motor (without purchase tax) | £100<br>£140 | 350 gal. per week and continuous refrigeration = 3,120 kWh* | £13 0 0 |
| C | 3 (*b*) | Do. | Do. | 350 gal. per week and incidental refrigeration P.E.R. = 3·0 2,000 kWh† | £8 7 9 |
| D | | Minimum savings in operating cost and consumption per annum | *N.B.*— Total cost saved in 7 to 9 years | 3,680 kWh per year (A-B) | £15 10 0 (A-3) |

* Heat rejected to heat leak at lower temperature when heated water is not used.
† Figures have been rounded up slightly.

time will use about 20 kWh. per week and a small one about 15. Making full allowances for the losses occurring at each stage, it should be possible to obtain a performance energy ratio of at least 3 from a dual-purpose heat pump driven by a motor of ¼ h.p. (400-500 watts). From these considerations Table II has been prepared showing the comparative costs and the savings effected. These last can easily amount to £15 per annum.

The heat pump system can take various forms. The simplest is that which has the hermetic unit and condenser immersed in the hot-water tank which is above or adjacent to the larder to be cooled. An alternative arrangement is to have a small circulating tank in the larder and the main storage tank upstairs—a system directly comparable to the normal boiler circuit. As the rate of heat input is low, insulation must be good to avoid excessive losses. In order to have continuous refrigeration, it may be necessary to provide a " heat leak " (possibly an un-insulated tank) which can be switched into circuit when the main storage tank has been fully heated.

Detailed results of the investigation, which is still proceeding, cannot be given, but it can be stated that: (1) It is possible to provide hot water at 140 deg. F. (which is the highest temperature for trouble-free storage of hard water); 40 gallons being heated in 10 hours. (2) It is possible to cool the substantial volume of a 50-cub. ft. larder to 40-45 deg. F. in summer and to provide at the same time a smaller space at 30-35 deg. F. (3) It is possible to do this with a performance energy ratio of at least 2·0 for water heating.

Heat pumps of this capacity would also have a potential market in dairies and similar establishments, and trials are being arranged. The dual-purpose characteristic has been stressed owing to the fairly high first cost which exists at present, but experience has shown that the theoretical performance energy ratio of 3 can be achieved in practice. Several large-capacity heat pumps have been operating in this country for years, and much experience is being gained on the one installed in the Electrical Research Association's buildings.

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## OIL PROSPECTING AND GAS TURBINES

### *Documentary Films*

Three documentary films made for the Royal Dutch and Shell Group of oil companies were presented at a film show given in Shell-Mex House, on Monday, November 29, and included one photographed mainly in the jungles of Indonesia, entitled " The Search for Oil," and another of an explanatory nature called " The Gas Turbine." The third film provided a record of " The Dutch T.T.," and showed the 1954 motor-cycle events for the Netherlands Grand Prix at Assen.

" The Search for Oil," which is of both technical and aesthetic interest, illustrates the prospecting work which must be completed before a test-well or " wildcat " can be drilled. Animated diagrams and site photography indicate the methods by which geologists forecast the areas where deposits of oil are likely to be found, and such processes as map-making by aerial photography; geological, gravimetric and seismic survey; and fossil interpretation, are described. The film shows the way in which information from these different sources is combined to form a picture of the underground rock formations, from which can be estimated the best locations for drilling.

By sharp and detailed observation the film conveys a vivid impression of the work involved and the country in which it takes place, and occasionally introduces a lighter mood, as when a sequence showing a geologist examining seismic records is cross-cut to reveal a monkey engaged in similar grave contemplation of a leaf. " The Search for Oil," was produced by Sir Arthur Elton, who, with John Grierson, helped to found the theory and practice of documentary film, and was made with the assistance of the Geological and Production Department of N.V. de Bataafsche Petroleum Maatschappij.

The Shell Film Unit's 100th production is an instructional film giving a simple and direct picture of the basic principle employed in the gas turbine, for both its jet and shaft power-producing forms. By demonstrations and analogies, with a sectioned engine and comprehensive animated diagrams, the film demonstrates the operation of the gas turbine, showing its fundamental similarity to all other heat engines. It also refers to the main uses of the gas turbine in the air on the ground and at sea. " The Gas Turbine " is a film easily understandable by the layman and is suitable for instructional purposes in schools, technical colleges, universities and elsewhere.

The running time of this film is 15 minutes, and of " The Search for Oil " 31 minutes; both films will shortly be available from the Petroleum Films Bureau, 29 New Bond-street, London, W.1. Overseas they will be distributed through Shell companies. " The Dutch T.T.," which runs for 39 minutes, will also be obtainable from Shell-Mex and B.P. Limited, Public Relations Department, Shell-Mex House, Strand, London, W.C.2.

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## INTERNATIONAL STUDENT EXCHANGE

### *Gaining Technical Experience Abroad*

Countries as remote as Iceland, Israel and the United States now take part in the IAESTE scheme, whereby students can seek technical experience abroad during their vacations, and in 1954 the number of students exchanged was 4,267. The Seventh Annual Report (1954) of IAESTE (The International Association for the Exchange of Students for Technical Experience) has now been published and, in addition to covering the year's activities, gives a summary of the development of the Association's work from 1948 to 1954.

IAESTE is in consultative relationship with UNESCO and the United Nations Economic and Social Council, and since it was founded in 1948 has dealt with the exchange of more than 17,800 students. During the past year Portugal has been admitted to the Association and India and Turkey have applied for membership; student exchanges between Turkey and member countries have, however, also taken place in 1954 but are not included in the number quoted above. These applications will be considered at the Annual Conference in January, 1955.

The Report lists the exchanges made during the year by the countries in the Association and gives the distribution of students among various technologies. Figures for the average age and payment of students are provided, and in the reports submitted by the participating countries are named the institutions and industrial organisations which have assisted in the scheme.

In general, students taking part are able to select both the country they will visit and the branch of technology in which they will be engaged, but this depends, of course, on the vacancies available. Experience usually takes the form of factory work, but visits to places of interest are also frequently arranged. Special concessions for visas and travel are made by many countries, and accommodation is frequently found for the student in advance. Payment is normally in accordance with local student rates.

The importance of the Association's work is indicated in a report by the General Secretary of the Engineering Institute of Canada, who said that its value was twofold: firstly the promotion of international relations—the scheme helped to foster in the minds of young men, who would eventually be leaders in their own countries, appreciation and understanding of other countries. Secondly, it was of great value to the student to see how business and engineering was conducted in countries other than his own.

The General Secretary of IAESTE is Mr. J. Newby, Imperial College, South Kensington, London, S.W.7.

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## GLASGOW'S TRANSPORT

### *Possible Extension of Underground Railways*

The possibility of constructing a new underground transport system in Glasgow, extending perhaps 20 miles to serve new housing areas, was discussed in Glasgow recently by the Municipal Transport Committee and a representative of Sir William Halcrow and Partners, consultants to Glasgow Corporation. The representative said that new underground construction would be the answer to the city's transport problem. His view was that, while electrification of suburban railways would ease the situation, it would not offer the whole solution.

He discussed the possibilities on the basis that to serve some of the largest new housing areas, 20 miles of new underground construction might be necessary, costing £4,000,000 a mile on wholly sub-surface sections and £1,000,000 a mile on other sections. It was explained that such a scheme would have to be the subject of a detailed examination by the consultants, keeping in mind the specific areas which might be served in that way and on which the Corporation would have to make their suggestions. The main immediate outcome of the talk was a recommendation that the subject might be raised in the joint committee of Glasgow Corporation and the British Transport Commission, who are considering plans for electrification of suburban railways in and around Glasgow. It was suggested that the committee might be interested in obtaining a more detailed report from the consultants who, so far, have given the Corporation an interim report. In this interim report they advised against any further consideration of an extension of the existing underground because of the difficulty and cost that would be entailed in bringing the tunnels and platforms up to standard size.

Expressing his personal view, Councillor Robert McAllister, convener of the Transport Committee, said after the meeting that at some time or other the Corporation would have to face up to the question of new underground construction. It could be linked with an electrified railway system as in London. When the subject was discussed a little time ago, with particular reference to the high cost of underground construction, the convener suggested that much greater financial resources than those of Glasgow Corporation alone would have to be available, and he saw possibilities in that direction in the formation of a passenger transport board for the West of Scotland on the lines of the London system.

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## CONFERENCE ON AIRCRAFT PRODUCTION

The Southern Section of the Institution of Production Engineers is to hold the third annual conference on " Problems of Aircraft Production" at Southampton University on January 14 and 15, 1955. The object of the conference is to bring together senior executives responsible for the design and production of aircraft.

The theme of the conference is to be " Integral Construction Contrasted with Traditional Methods." Full details and application forms may be obtained from the secretary of the Institution of Production Engineers, 10 Chesterfield-street, London, W.1. The last day for application is Wednesday, January 5. The conference fee is 30*s.* for members of the Institution and affiliated representatives, and 35*s.* for non-members.

## CONTRACTS

**Fighter Aircraft.** The Canadian Government have given a development contract to A. V. ROE CANADA LTD., for new C105 fighter aircraft. These are described as twin-engined supersonic, long-range all-weather aircraft of "very advanced" design. The company have also developed a jet engine in which titanium is employed.

**Blast Furnaces.** A contract for two large blast furnaces, amounting in value to nearly £3 million, has been placed by the Indian Iron and Steel Co. Ltd., with ASHMORE, BENSON, PEASE & CO., Stockton-on-Tees, a member firm of the Power-Gas Group. The furnaces, to be built at Burnpur, India, will have hearths of 25 ft. diameter, and each will be capable of an output of 1,200 tons of iron a day. The first furnace will go into production in 1958 and the second a year later.

**Airliners.** Capital Airlines, Washington, U.S.A., have exercised their option to purchase, from VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, Westminster, London, S.W.1, 20 further Vickers Viscount propeller-turbine airliners. This brings the total number of Viscounts ordered by Capital Airlines to 60, and, to 83, the total number of the airliners sold to North America. The other North American orders are for 22 aircraft for Trans-Canada Air Lines and one for the Canadian Department of Transport. The total value of these 83 aircraft is 84·8 million dols.

**Oil Gas Plant.** The Eastern Gas Board have placed an order with the POWER GAS CORPORATION LTD., Stockton-on-Tees, for a Segas catalytic installation for producing town gas from heavy fuel oil, at Ponders End Gasworks. The installation will produce 3,200,000 cub. ft. of gas a day and all the necessary ancillary equipment, gas cooling and naphthalene-removal plant will also be provided. The installation is due to be in full operation by the autumn of 1956. It may be recalled that we gave an illustrated description of the Segas plant installed at the Lower Sydenham Gasworks in our issue of January 8, 1954, pages 34 and 52.

**Electric-Railway Signalling Equipment.** The Eastern Region of British Railways have awarded a contract to the SIEMENS AND GENERAL ELECTRIC RAILWAY SIGNAL CO. LTD., for carrying out the alterations to the signalling necessitated by the forthcoming electrification of the 9½-mile double track section between Shenfield and Chelmsford. Primarily the work involved is the adaptation of the existing signalling installation to the new conditions imposed by the introduction of a 1,500-volt direct-current overhead electric traction system, but the contract also includes the supply and installation of telecommunication cables. The existing mechanical-lever frames at Ingatestone and Chelmsford will remain, but will be equipped with additional electric lever locks to provide the new control conditions. A complete power distribution system at 650-volts, 50-cycles, single-phase, alternating current will be provided throughout with switchboards, transformers and other equipment, at Ingatestone and Chelmsford signal-boxes.

**Railway Rolling Stock.** The British Transport Commission have placed orders with the BIRMINGHAM RAILWAY CARRIAGE AND WAGON CO. LTD., Smethwick, Staffordshire, for 100 third-class saloon coaches, with centre gangways, and 97 twenty-ton ballast brake vans fitted with ploughs.

**Coke-Oven Machinery.** THE WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD., Parnell House, Wilton-road, London, S.W.1, have received from Simon-Carves Ltd., Cheadle Heath, Stockport, a contract for the supply of two sets of coke-oven machines to be installed at the Burnpur Steelworks of the Indian Iron and Steel Co. Ltd. The equipment will comprise two portal-type coke pusher, coal-leveller and door-extractor machines, two coal-charging cars of the four-hopper type, three combined coke-guide and door-extractor machines and eight clay carriers. Particulars of the main contract, which is for two batteries each of 78 coke ovens, will be found on page 652 of our issue of November 19.

**Power Plant.** The North of Scotland Hydro-Electric Board have placed orders for the supply of new generating plant for their steam station at Carolina Port, Dundee. JOHN BROWN LAND BOILERS, LTD., Clydebank, will build the steam generating plant with ancillary equipment, comprising two 150,000 lb. of steam per hour stoker-fired boiler units. THE ENGLISH ELECTRIC CO. LTD. will supply the 30,000-kW turbo-alternator together with the main and auxiliary transformers.

## BOOK REVIEWS

**The Coneygre Story.** By W. K. V. GALE. *Coneygre Foundry, Limited, Tipton, Staffordshire.* (Free on application.)

Ironstone was mined near Tipton as long ago as the late Thirteenth Century. A blast furnace is known to have been at work near Coneygre (pronounced Conny-gree) in 1625, and a forge in 1717, so that the present Coneygre Foundry, a subsidiary of the Birmid Industries Group, can claim an unusually long ancestry. In this compact but comprehensive history, Mr. Gale has demonstrated once again his expert knowledge of the iron industry in his native Black Country and his ability to present the story of a particular unit against the economic background of its environment. The first chapter, for instance, not only introduces the reader to Coneygre, but explains with notable lucidity how the industries of Tipton and its neighbourhood developed as they have done over the past three centuries. The second chapter is devoted more specifically to the Coneygre furnaces and is followed by a plan, on tracing paper, of Coneygre in 1849, superimposed on a reduced-scale Ordnance map of 1954, showing the present works. The third and fourth chapters, covering the Nineteenth Century and the first half of the Twentieth, are naturally less dependent upon deductions from somewhat sparse historical data, the records for the period being still available. They tell a story of repeated expansion and re-equipment, resulting in the growth of the plant from a small works, employing only a score of men 50 years ago, to one of 120,000 sq. ft. which employs to-day some 450. The fifth and last chapter describes the present works, principally engaged in producing repetition grey iron and alloy iron castings, and specialising in cylinder blocks and brake drums for the motor-vehicle industry.

**Oil Tanker Cargoes.** Their Safe and Efficient Handling. By JOHN LAMB. *Charles Griffin and Company, Limited, 42 Drury-lane, London, W.C.2.* (18*s.*)

This is an instruction book written for the benefit of engineer and navigating officers of oil tankers. Vessels of this class have increased in number to such a remarkable extent in recent years that there must be many seagoing engineers finding themselves in charge of the specialised equipment of oil tankers and yet with little experience of the many problems inherent in the handling of oil in bulk. As a background to his main subject, Mr. Lamb begins with a brief history of oil-carrying ships ranging from the brig Elizabeth Watts, of 224 tons, which carried the first oil cargo across the Atlantic in 1861. The oil, crude petroleum, was carried in wooden barrels but a few years later the sailing ship Charles was equipped with iron tanks to hold the oil. This led to what now appears to be the fairly obvious step of carrying the oil in bulk in the ships' holds. The development up to the large tankers of to-day is traced, particular reference being made to questions of the sub-division of cargo spaces, the position of the pump rooms and the lay-out of pipe systems.

These latter matters have direct bearing on problems of loading, discharging and the treatment of cargoes during transit, which are the main subjects of the book. The procedure to be followed during these various operations is explained in detail and with clarity. The handling of low-flash cargoes naturally presents the greatest hazards. It is stated that cargoes of this type are discharged at some 160 ports. At about half of these, shore steam is available for operating the pumps, but at the rest the tankers own boilers must be in operation. This imposes rigid safety precautions, the nature of which is clearly described. Problems other than those of explosion or fire hazards arise in all discharging operations, and the sequence of discharging the various compartments to avoid undue stresses being set up in the ship, the procedure to be followed when a tanker is unloading under low-temperature conditions of the surrounding water and many other matters of procedure are dealt with.

Although the handling of low-flash cargoes involves the greatest risks, heavy oils present their own problems. It is recommended that, during a voyage, viscous cargoes should be maintained in a fluid condition by supplying steam to the heating coils for a few hours daily; allowing them to cool and supplying heat only at the end of a voyage is likely to delay discharge. Special cargoes such as bitumen, butane and propane are dealt with. Bitumen requires specially-designed ships as the cargo must be kept unusually hot. It is loaded at a temperature of between 250 deg. and 350 deg. F. and it is recommended that a mean temperature of 220 deg. F. should be maintained at sea. Butane and propane are carried in cylindrical pressure containers which may be mounted in the centre compartments of an oil tanker. This informative book describes the methods of handling these liquified gases in the same detailed manner as those relating to the various classes of oil.

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## BRITISH STANDARDS

*The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.*

**Definitions for Use in Mechanical Engineering.** (6*s.*, post free.)

The latest addition to the series of what may be termed basic engineering standards is that entitled "Definitions for Use in Mechanical Engineering" and designated B.S. 2517. The definitions given relate to terms of general application in the engineering industry, and the eight sections into which the standard is divided deal, respectively, with construction, drawings and schedules, geometry of parts, size and tolerance, limits and fits, screw threads, surface texture, and gauges. Ambiguity in the use of common terms frequently occurs and inevitably leads to confusion. The aim of the new publication has been to provide a logical code of definitions which are both clear and consistent. Students will find the publication of great assistance to them in their appreciation of the theoretical conceptions on which all practical engineering is based. Numerous illustrations are included and an alphabetical index provided for easy reference. Each definition has been given a number; those in Section 1, on construction, being designated 0101 awards, those in Section 2, on drawings and schedules, 0201, 0202, etc., and similarly to Section 8 which deals with gauges, where the definitions have been numbered 0801 to 0813.

**Graphical Symbols for Electrical Purposes.** (Amendments gratis on application.)

Users of circuit diagrams find it convenient to define classes of components, and to identify particular components in a class, by employing code letters or component references. For this purpose power-supply engineers employ the symbols given in the 1951 edition of B.S. 108, covering graphical symbols for general electrical purposes. On the other hand, persons in the telecommunications industries consult the supplement to B.S. 530, published in March, 1950. At the time of issue each standard reflected the conventions that had grown up in the field of technology concerned, and, in consequence, there were some inconsistencies between them. For instance, a capacitor was given as Cp in B.S. 108 and as C in B.S. 530, C being a contactor in the former publication. In power diagrams TR indicated a tripping relay, but in telecommunication diagrams it indicated a transformer. As a result of much discussion between technicians in both fields these differences have now been removed; the issue of amendments PD 1952 (to B.S. 108) and PD 1953 (to the supplement to B.S. 530) show the extent to which the two classes of users have met half-way. As examples, a capacitor is now C to all users, Con: being the abbreviation for a contactor. TR remains tripping relay, the transformer of B.S. 530 having become T to conform to B.S. 108.

**Engineers' Comparators for External Measurement.** (2*s.* 6*d.*, post free.)

Many advances in the design of measuring instruments have been made since the Institution first

issued B.S. 1054, covering engineers' comparators for external measurement, and these instruments are now made with magnification factors of 10,000 and over. The standard, accordingly, has been revised and the new edition now issued includes provisions for these more sensitive instruments. The opportunity has also been taken to clarify certain of the general requirements. Development in this field is, of course, a continuous process and it would be unsuitable to lay down design requirements which might have a restrictive effect. The aim, therefore, has been to confine the clauses to such features of the instrument as are essential to enable it to meet and maintain the specified accuracy. The publication relates primarily to comparators of the vertical type, but may be adopted for horizontal types in so far as the requirements are applicable. In addition to stating requirements for features such as the worktable, measuring anvil, pointer, and scale, standards of performance are laid down and tolerances on scale readings are specified in inches and millimetres for comparators of various degrees of sensitivity within the ranges covered by the standard.

**Boiler-Water Treatment and Testing of Boiler-Water Deposits.**
(Two standards, each 6*s*. post free.)

Two new standards relating to boiler water have been issued ; one, B.S. 2486, concerns the treatment of water for land boilers, and the other, B.S. 2455, describes methods of sampling and testing boiler-water deposits. Specification B.S. 2486 is particularly directed to the needs of operators of steam-generating plant as used widely in industry and usually operated at a pressure not exceeding 250 lb. per square inch. The purpose of the standard is to show how impurities in the water affect boiler plant and to assist in the application of an economical method of treatment suitable to the individual supply. The publication is divided into parts dealing with water supplies and their treatment, feed water and boiler water, and the care of boiler installations. In addition, a glossary of terms used in water treatment is included as an appendix.

Specification B.S. 2455 is divided into sections in which the terms used are explained and methods are recommended for collecting and describing samples, for their chemical and physical examination and for reporting the results obtained. The methods of chemical examination have been selected so as to require the minimum of time, consistent with yielding results of an accuracy adequate for the purposes required. The determinations included comprise oil, loss on ignition, phosphate, carbonate, sulphate, chloride, sodium, silica, copper, iron, aluminium, calcium, magnesium and water-soluble salts.

**Manufacture and Testing of Refrigerating Cabinets and Cold Rooms.**
(Two standards, each 3*s*., post free.)

Two new standards, B.S. 2501, covering the manufacture and testing of refrigerating cabinets of the "reach-in" type, and B.S. 2502, relating to the manufacture and testing of sectional cold rooms of the "walk-in" type, have been prepared and issued, as it has been generally felt that the two existing standards have a very limited application. These are B.S. 922, which deals with electrical refrigerators and food freezers for household use in all climates, and B.S. 1691, concerning similar equipment for use in temperate climates. The two new standards are intended to make provision for larger commercial and industrial refrigerators, namely, cabinets of 12 to 100 cub. ft. net capacity, and sectional cold rooms of 100 to 1,500 cub. ft. gross capacity. As in the case of existing standards, no attempt has been made to recommend standard sizes; only conditions of manufacture and testing have been prescribed.

**Composite Units of Switches and Fuses.** (For Use in Industrial Systems and Domestic Circuits.) (3*s*., post free.)

To meet a demand for a standard for low-voltage and medium-voltage switches and fuses mechanically combined and connected electrically in series, the Institution have prepared and issued B.S.2510. The publication covers units with air-break switches which have not more than four fused poles and which are suitable for current ratings of up to 200 amperes, on domestic circuits, and for industrial systems in which the declared voltage does not exceed 250. The various sections into which the specification is divided deal, respectively, with ratings, construction, operation in service, the marking of the switches and fuses, and testing procedures. Two appendices are concerned with the selection of fuses and with temperature measurements. A list of definitions, and line diagrams of the connections for the test for making and breaking capacity, are also included.

## TRADE PUBLICATIONS

*Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.*

**Alignment Telescope.** TAYLOR, TAYLOR AND HOBSON, LTD., Leicester. Micro alignment telescope for observing thousands of an inch in displacement of collimator at distances of 18 in. to 150 ft. Accuracy 0·004 in. at 100 ft. Illustrated leaflet describing telescope and attachments for checking alignment, parallelism and squareness in machinery beds, etc.

**Improvements in Steam Plants.** SPIRAX-SARCO, LTD., Charlton House, Cheltenham. How to fit steam-traps ; air removal from steam and hot-water plant; how to lift condensate; practical considerations on steam for process, covering distribution and use of steam. Two illustrated leaflets, one illustrated booklet, one book "Steam for Process" with many explanatory diagrams.

**Scale-Formation Prevention.** G. & J. WEIR, LTD., Cathcart, Glasgow. Paper by Mr. H. Hillier on scale formation in sea-water distilling plants and its prevention. Statement of the problem with results of tests on scale formation. Various methods of treatment. Illustrated book with graphical results of tests and full treatment of chemical reactions.

**Grinding Wheels and Abrasives.** THE CARBORUNDUM CO., LTD., Manchester. Diamond products; "MX" grinding wheels; sharpening; "61 Port-a-Belt" portable belt grinder; optical powders; "Flexbac" marking rope; instructional films, all with sound, some in colour, on aspects of grinding. Seven illustrated pamphlets.

**Colloidal Graphite.** ACHESON COLLOIDS LTD., 18 Pall Mall, London, S.W.1. "Dag" dispersions of colloidal graphite with useful lubricating and parting properties when applied to dies and tools used for hot metal-working operations; range of dispersions based on various liquid carriers. Illustrated pamphlet.

**Tyre-Mould Profiling Miller.** FRIEDRICH DECKEL, Waakirchner Strasse 7-13, Munich 25; Agents BURTON, GRIFFITHS & CO., LTD., Mackadown-lane, Marston Green, Birmingham 33. Model KF 12 R for moulding tyres up to 43·3 in. in diameter. Illustrated pamphlet with all information in English and German.

**Belt Drives.** J. H. FENNER & CO. LTD., Marfleet, Hull. Standard V-belts, V-belt pulleys, "Hainsworth" variable-speed drives. Drive-design data. V-belt applications, belt tension, faults. Catalogue 120/14 replaces earlier editions; comprehensive, well-illustrated, with full standard drive tables.

**Multi-Purpose Hand-Tool.** BROOKS & WALKER, LTD., 47 Great Eastern-street, London, E.C.2. "Diprofil" reciprocating hand-tool driven by electric motor through flexible shafting; files, saws, scrapers, hones, laps can be used, also certain rotating tools with special extension. Illustrated leaflet.

**Synthetic Resin Glues in Building.** AERO RESEARCH LTD., Duxford, Cambridge. Use of "Aerolite 300" for timber roof trusses. Bulletin reviewing some research on strength of such trusses and describing commercial applications where Aerolite roof trusses have been built.

**Copper Jointing Strips.** IMPERIAL CHEMICAL INDUSTRIES LIMITED, Metals Division, Kynock Works, Witton, Birmingham. Corrugated copper jointing strip for expansion joints in concrete for retaining walls, road slabs, bridges, etc. Illustrated leaflet specifying strips and explaining use.

**Guards for Kiln Rollers.** CEMENT MAKERS' FEDERATION, 52 Grosvenor-gardens, London, S.W.1. Booklet illustrating the several patterns of guards now in use for cement-kiln rollers. Criticism and suggestions invited by the Federation's advisory committee on accident prevention.

**Hydraulic Machine Vice.** B. ELLIOTT & CO., LTD., Victoria Works, Willesden, London, N.W.10. "Victoria" Hydrovice with plain or swivel base, 5-in. jaws, two models opening to 3⅛ in. or 6 in. Pressure on jaws up to 14,000 lb. Illustrated leaflet.

**Bolt Threading Machine.** MAIDEN & CO., LTD., Hyde, Cheshire. Type "PR," 1-in and 1¼-in. sizes for production work on all forms of parallel threads with radial- or tangential-type die heads; three-speed gearbox and multi-disc friction clutch. Illustrated leaflet.

**Oxygen Cutting.** HANCOCK & CO., LTD., Progressway, Croydon. Range of oxygen-cutting profiling machines, with brief outline of the cutting process. Illustrated booklet.

## BOOKS RECEIVED

*Some of the books noticed in the Books Received column are selected for extended review in later issues of* ENGINEERING.

**Fluid Mechanics: With Engineering Applications.** By R. L. DAUGHERTY and A. C. INGERSOLL. Fifth edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (50*s*.)

In the fifth edition of this book, the original title "Hydraulics" has been changed in order to emphasise the fact that the treatment is not confined to water or even liquids, but is applicable to all fluids, including vapours and gases. Fundamental concepts of fluid mechanics are introduced one at a time, starting with a treatment of fluid properties, and progressing through fluid statics, kinematics and dynamics, all developed for a general fluid. The remainder of the text is devoted to applications of these fundamentals. The information included on experimental data makes the book of interest to practising engineers, as well as to engineering students.

**Elements of Food Engineering. Vol. II: Unit Operations.** By MILTON E. PARKER, ELLERY H. HARVEY and E. S. STATELER. *Reinhold Publishing Corporation*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (8·50 dols.) ; and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (68*s*.)

Published in three volumes, this book treats the production, preparation, processing, handling and distribution of foods from the unit operation and unit process points of view. Volume II covers those operations involved in assembling and preparing raw materials, and discusses such aspects of raw material conversion as mixing, heating and refrigeration.

**Control-System Dynamics.** By WALTER R. EVANS. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7 dols.) ; and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (50*s*.)

This book is designed to demonstrate the techniques for determining the response of linear control systems. It is primarily an exposition of the root-locus method invented and developed by the author. In the root-locus method, the component in a control system is described by the roots of the characteristic equation of that component, and the roots are determined graphically.

**Coal Mines in Canada.** List 4-1. *Department of Mines and Technical Surveys, Mines Branch, Mineral Resources Division, Ottawa, Canada.* (25 cents.)

This publication presents operating data on coal producers in Canada. Coal producers are divided into two categories, active and inactive. The former includes producers who reported production to the Dominion Bureau of Statistics during 1952 or 1953, and who were still in business on January 1, 1954. The latter includes those who reported production in 1951, but did not produce during 1952 and 1953.

**Thermal Conductivity of Metals and Alloys at Low Temperatures: A Review of the Literature.** By ROBERT L. POWELL and WILLIAM A. BLANPIED. U.S. National Bureau of Standards Circular 556. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (50 cents.)

This circular is issued to satisfy the need for a complete and authoritative compilation of the data on thermal conductivity at low temperatures given in the widely-scattered and extensive literature on the subject. Although the circular is not primarily a critical compilation, the text indicates a method that might be used in choosing between conflicting data.

**Fire Protection Year Book, 1955.** Compiled by GEOFFREY F. D. PRATT. Fifteenth edition. *Benn Brothers, Limited, Bouverie House*, 154 *Fleet-street, London, E.C.*4. (12*s*. 6*d*.)

In this edition the list of senior Fire and Salvage Corps officers has been extended to include the names of deputies, and some rearrangement of the directory sections has also been made for ease of reference. The sections dealing with the public fire services in the British Isles, and the industrial and private brigades of the United Kingdom, respectively, have been enlarged, and a more precise breakdown of calls received is given. Chapters devoted to legal aspects and fire engineering have been revised and enlarged.

*Autumn Meeting of the Iron and Steel Institute* (*continued from page* 723)

# CONTINUOUS CASTING OF STEEL

## PREVENTION OF BILLET RUPTURE

Continuing our report of the annual autumn meeting of the Iron and Steel Institute held in London on November 17 and 18, we now deal with the final paper considered at the morning session on November 17. This, by Mr. J. Savage and Mr. W. H. Pritchard, of the Physics Department of the British Iron and Steel Research Association, dealt with "The Problem of Rupture of the Billet in the Continuous Casting of Steel," and was presented by Mr. Savage. The authors stated that the rupturing of the billet skin in the mould was a long-standing problem in the continuous casting of steel. It was caused by a combination of high frictional forces between the billet and the mould surfaces and the relatively low tensile strength of the billet skin. The present work had brought out the essential differences between the Junghans, or reciprocating system, and the spring-mounted mould system which had been introduced with the object of obviating billet rupture. In the first, any sticking during the period of relative movement of the billet and mould could rupture the skin on account of the very rapid rise of the stresses, but an adequate safeguard was provided over a wide range of casting speeds. In the second system, which had been patented in the United Kingdom by B.I.S.R.A., sticking introduced automatically, and without rupture, a mechanism for strengthening the billet skin to a value at which it could withstand the force necessary to strip the billet from the mould wall. Rupture of the billet skin was thus prevented, instead of the consequences of rupture being merely circumvented.

### BRITISH PILOT PLANT

Mr. G. T. Harris, who opened the discussion, stated that the paper put on a firm scientific basis a good deal of what had already been published in the patent literature and elsewhere without any very adequate explanation of the scientific reasons behind the success or otherwise of these moulds. The Junghans mould had been applied in many different plants in America and on the Continent, and in one in this country, and the B.I.S.R.A. mould had been applied to a pilot plant in this country.

This plant was in some sense a private venture, financed by a group of eleven interested steel companies which wanted to know how this system could be applied to the special-steel industry and in particular to the casting of high-speed steel. The group, which ran the plant at the works of Wm. Jessop and Sons, Ltd., Sheffield, was at present a little reticent about disclosing too much of the operating experience, preferring to wait until a reasonable measure of success had been attained and the co-operating members could have the opportunity themselves of putting down plants. For that reason he could not enlarge very greatly on the practical fulfilment of the system outlined by the authors, but it was fair to state that in the six months during which the plant had been operated at Jessops there had been no undue difficulty through failure of the plant or of the process due to the frictional problem discussed in this paper. In other words, the solution of the friction problem which has been provided by the B.I.S.R.A. mould had worked out satisfactorily in practice.

As Mr. Savage had pointed out in presenting the paper, the mould was only one of the many problems associated with the commercial application of continuous casting. It was necessary to make the steel and tap it, as a rule, at a temperature in excess of that desirable for the best steelmaking practice, and there was the problem of maintaining it at an excess temperature in the ladle. This involved special refractory problems, and, if a slag were present on top of the metal to prevent some of the radiation losses, it involved special techniques to ensure that none of this slag went through the system into the continuous casting mould.

Mr. D. M. Lewis said that his interest in continuous casting now lay with light alloys, and there was a general impression that these were very much easier to handle than steel. There were still difficulties, and a number of the findings in studying the casting of aluminium might be of importance and help to clear up some of the rather mysterious features that the B.I.S.R.A. team had met from time to time.

He had been disappointed at not seeing, in the paper, any metallographic evidence for the tearing theory which the authors had proposed. There should be little difficulty in obtaining etched sections showing the progress of rupturing. With aluminium it was easy to obtain etched sections which showed what had happened in a breaking process.

### POSSIBILITIES OF THICK-GREASE LUBRICATION

The amount of work done on mould friction was interesting, and provided overwhelming evidence for proper lubrication. The authors favoured the addition of oils, but had they examined the effect of very thick greases applied to the mould before a run commenced? In some work at Aluminium Laboratories Limited, Banbury, it had been found that molybdenum disulphide grease in a thick coating could be very successful for some aluminium alloys. Such greases might be useful with steel.

The authors appeared to rely on a variant of the pour-out method for getting a knowledge of solidification contours. This was somewhat unfortunate, as it was now accepted that the pour-out method was most misleading and unreliable. Much more useful results could be obtained by using some of the tracer techniques described by Mr. J. L. Putnam and himself in Institute of Metals papers earlier in the present year.

In conclusion, he would like to emphasise the extraordinary importance of metallurgical examination of the casting process at the same time as the purely physical study. Experience at Banbury had shown repeatedly that the physical state, on its own, could be seriously misleading. It was overwhelmingly important to know the exact composition and characteristics of the metal being cast, because investigators were dealing with a phenomenon occurring at or around the melting range. Mr. Harris had said that very little information was available concerning the properties of the metal at those temperatures. A metallurgical study of sections of failed billets or ingots might yield considerable information which would furnish a guide regarding what occurred in this mould region.

Dr. V. Kondic asked what were, on a very broad basis, the most essential differences between the continuous casting of ferrous and of non-ferrous metal alloys. They fell into two categories, namely (i) metallurgical and physical differences, and (ii) production differences. In the first group the most important variable was the magnitude of the temperature difference. The temperature difference between the highest and lowest temperature ingots was very much greater in the non-ferrous metal field, and, further, the extent of that temperature difference could be varied in the non-ferrous metal field much more freely than in the ferrous-metal field.

The second variable, in order of importance, between the two fields was that of freedom of quenching. In non-ferrous metal casting, quenching methods could be chosen relatively freely, but there was not this freedom in the case of steel.

Turning to the production side, the main difference was that of production rates and size and shape of ingots. While in the non-ferrous metal field it was almost general that continuous casting could turn out ingots faster than it was possible to melt the metal, the practice in the ferrous field was quite the opposite, and it was much more difficult to catch up with the production melting rates than it was to cast too rapidly. On the question of size and shape, on the whole, ingots in the ferrous-metal field were very much larger than they were in the non-ferrous metal field, with some exceptions in the light alloys.

Non-ferrous metal experience indicated that it was essentially with the pasty alloys that it was difficult to control rupture. On the other hand this control was relatively easy in the case of the continuous casting of eutectics and pure metals of any size and shape. An example was furnished by the continuous casting of cast iron. Any iron could be melted in the cupola and a good result obtained, and it could almost be said that cast iron could be continuously cast in any conditions, the reason being that there was freedom of choice of the pasty zone. When, however, the low-phosphorus pasty type of grey irons were involved the problem of rupturing arose.

Both the practical solutions for controlling mould rupture which the authors gave were based on the principle of leaving the ingot skin to form relatively quietly and then exerting a pull when the thickness was strong enough to resist the stress. Apart from that principle, which was utilised in the B.I.S.R.A. and other patents, one other solution had been omitted, that of a rotating mould, which performed the same function.

### IMPORTANCE OF LENGTH OF MOULD

The main difference between ferrous and non-ferrous metal casting practice was that while in non-ferrous practice, the mould could be shortened to 2 to 3 in., and the liquid concentrated in a very shallow region with the solid skin in a very narrow zone, the ferrous investigators had gone to the other extreme and produced a rather long skin. They had trouble in controlling its strength and the phenomena connected with it.

Instead of controlling the skin, the control of the force which was the origin of the rupture might be considered, because if it were not for the tension in the mould there would be no rupture in any case, whatever was being cast. The methods which had been suggested by the authors could be amplified by one addition, that of using vibration in the mould.

Dr. B. H. C. Waters stated that in the early days of the consideration of continuous steel casting in this country, there had been considerable discussion, in a somewhat dilettante way, on the effect of lengthening and shortening the mould. Would the authors care to comment on the question of how long the mould should be made? What was the optimum length? If the fabrication difficulties could be overcome, it might be possible to think in terms of a mould 10 ft. long instead of the 13 in. mentioned in the paper. The question of lubrication with a grease might be important, but it was very difficult indeed to get a grease which would maintain any kind of viscosity and remain in the mould for any length of time at the temperatures involved in casting steel.

In reply to the discussion, Mr. J. Savage agreed that there was a great void in existing knowledge of the thermal constants of steel and the rupture strength of steel, and particularly of special steels, between 1200 deg. C. and the melting point. It was very difficult to maintain a grease as a lubricant in the case of steel. It was all right for a few pounds of steel, but the grease tended to volatilise and after a time no more lubricant was left, so that continuous injection was necessary, and from that point of view grease was out of the question.

Dr. Kondic had made the point that apart from the Junghans reciprocating mould and the B.I.S.R.A. flexibly-mounted moulds, there were other mould systems which might be considered

from the point of view of overcoming rupture, and he had mentioned particularly a vibrating mould. Presumably, he meant one vibrating either laterally or longitudinally at relatively high frequency. There were numerous patents on this, but he did not know of any practical use of the system. It existed on paper, but they had only referred to systems which had been found practical and were being used.

Mould length presented a very difficult problem. Ideally, a mould should be just long enough, so that the rate of heat transfer obtained at the bottom of the mould was at least well above the normal radiation value. If the mould were cut too short there would still be obtained a reasonable degree of heat transfer in calories per square centimetre per second. On the other hand, if the mould were made too long the rate of heat transfer would fall to a very low value and no useful work would be obtained. It was, therefore, necessary to make the old engineering compromise between what was practicable and what was theoretically ideal.

There was one knotty point which had not been raised in the discussion. The title of the paper referred to billets. He and his colleagues did not regard the product from a continuous-casting plant, the as-cast product, as a billet; they only called it a billet because the size was that of what was normally understood by a billet in a steelworks. The whole question of ingot or bloom or billet was one of size and hot working. The structure of their billets was not directly comparable with that of a billet rolled down from an ingot through the bloom stage. They regarded the as-cast structure as something between the normal ingot structure and the rolled billet structure.

The meeting was then adjourned until 2.30 that afternoon.

*To be continued*

* * *

## STUDIES OF IMPROVED WELDING

Metallurgical research now being carried out by the British Welding Research Association was demonstrated during two " Open Days " held on November 23 and 24 at the head office of the Association at 29 Park-crescent, London, W.1.

Several varieties of cracking can occur in welded steel joints, and about a year ago the Association initiated work on the fissuring which may take place in weld metal. This assumes the form of fine intergranular cracks situated transverse to the welding direction. It has been found that the hydrogen content of the metal, the type of electrode used, and the rate of cooling, all have an influence on the occurrence of fissures. In connection with these and other experiments it is convenient to be able to introduce hydrogen into small steel specimens which are subsequently to be tested by various means. This is most conveniently accomplished by making the specimen a cathode in an electrolytic bath using a solution containing arsenious oxide as a catalyst. For the determination of the hydrogen present in weld metals and the parent materials, vacuum-heating apparatus has been devised. The steel and aluminium-alloy samples employed range from 1 gramme to 10 grammes in weight and the volume of gas which may be handled varies from 0·002 ml. to 5 ml., at N.T.P. In the case of steels, the samples are heated at about 700 deg. C. and the volume of gas evolved is measured. The hydrogen fraction is then estimated using a palladium tube.

### BRAZED JOINTS

The creep testing of assemblies for marine turbines possesses many features of interest. In these tests, brazed lap joints, made in selected parent materials and brazing alloys, are mounted in special adaptors. The joints, prepared with predetermined gaps, are tested in pure shear at temperatures similar to those used in modern steam turbines. Each of the six testing machines used is coupled independently to a six-point temperature recorder, so that the thermal history and life of each specimen are accurately measured.

Two interesting demonstrations were staged, at intervals, during the Open Days. The first illustrated the value of improved power sources for the self-adjusting arc process. This demonstration was organised in conjunction with the Electrical Research Association. In parallel, work done on " drift " in power source output was also shown. The efficacy of the improved power-source characteristics was demonstrated by comparative welding tests of a stepped plate.

The second demonstration concerned a rapid method for the assessment of the " weldability " of steel using a dilatometer in conjunction with a function plotter. The method involves dilatation tests on small specimens which have been subjected to a thermal cycle simulating that received in the hardened zone of welded steel joints. To simulate the thermal cycle, the specimens are heated by means of a small high-frequency generator, and subsequently cooled in a stream of nitrogen or argon supplied at a controlled pressure and volume calculated to reproduce the cooling curve obtained for various sizes of fillet weld. A small hollow cylindrical specimen, measuring $\frac{1}{4}$ in. in diameter and $\frac{1}{4}$ in. in length, is used, and the principle of the dilatometer involves the conversion of the linear length changes into an electrical record, which is then plotted as one ordinate on the function plotter. This instrument can be used to plot a function directly, the chart-motor speed and the pen speed being independently controlled by the two variables. Dilatation is plotted as a horizontal ordinate and temperature vertically. A second pen travels at uniform speed across the chart, giving a time base, so that a time-temperature curve is plotted simultaneously. By this means data concerning the variation of end-of-transformation temperature with cooling rate can be obtained, and the weldability of a given steel assessed.

* * *

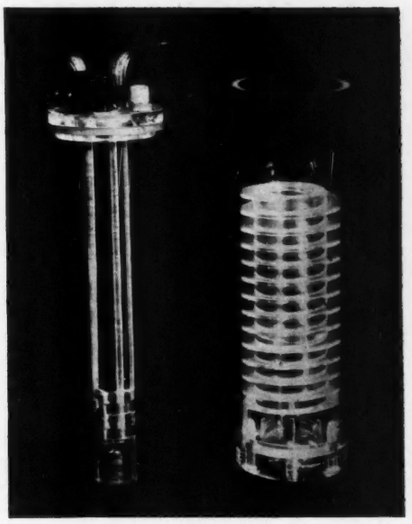
## DETERMINATION OF CARBON IN METALS

### *Conductimetric Methods for High or Low Values*

The determination of carbon in a large variety of ferrous and non-ferrous metals and alloys is necessary in connection with many industrial processes, and in recent years the accurate determination of very low carbon contents in certain ferrous materials used for electrical purposes has been required. In iron-silicon alloys for example, the hysteresis losses increase rapidly with increasing carbon content, the maximum permissible being 0·05 per cent. Similarly with nominally pure iron, interesting and useful magnetic properties are obtained with less than 0·1 per cent. carbon. The determination of carbon in these materials necessitates accuracy to at least three places of decimals, but the two techniques in fairly common use for such determinations both have certain disadvantages: one method is rather complicated and the other requires a fairly large sample.

A third method, which has been less commonly used, involves the determination of the carbon dioxide produced from the combustion of a sample of normal size (one or two grams) by an electrical conductivity measurement. This method has recently been further developed in the Research Laboratories of the General Electric Company, Limited, Kingsway, London, W.C.2.

Purified oxygen is supplied at a controlled rate to a mullite combustion tube containing the specimen in an aluminous porcelain boat. The combustion tube temperature is varied between 1,100 and 1,300 deg. C., depending on the material to be analysed. A special loading device permits the boat to be pushed into the hot zone of the furnace. The gases leaving the combustion tube are passed through granular manganese dioxide to remove oxides of sulphur and thence into the specially designed Perspex conductivity cell shown in the illustration. This contains a solution of caustic soda or barium hydroxide at a thermostatically controlled temperature, together with a trace of a non-ionic wetting agent.



**Carbon dioxide evolved from the combustion of the sample is absorbed by the solution in the cell, and the change in conductivity measured.**

The gas bubbles formed are made to follow a helical path about 55 in. in length, which ensures efficient absorption of the carbon dioxide. The solution circulates to the electrode chamber in the centre of the cell and the conductivity is determined by means of a Wheatstone bridge circuit using a 50-cycle alternating-current supply and a vibration galvanometer for null indication. The measuring cell itself contains only 45 ml. of solution, which gives high sensitivity, and is robust and very easily emptied and refilled. The conductimetric method also has the advantage of wide range, so that high-carbon cast irons can also be analysed.

Combustion of cast irons, iron powders, and plain carbon steels is complete and sufficiently rapid, without the use of fluxing or igniting materials. With all other alloys so far analysed, either lead or tin or both these metals have been found to be useful additives which do not introduce large errors. Lead is useful for iron-rich alloys and acts primarily as a flux. Tin acts mainly as an igniter and is most useful for alloys containing large amounts of nickel, cobalt or tungsten; with high-nickel alloys tin has an additional fluxing effect.

The results shown in the following table were obtained on two standard steels and one standard cast iron from the Bureau of Analysed Samples, Limited, Newham Hall, Middlesbrough.

| Carbon Present According to B.A.S. | | Carbon Determined by Conductimetric Method | |
|---|---|---|---|
| Average Per Cent. | Range Per Cent. | Values for Each Sample Per Cent. | |
| 0·029 | 0·0275 to 0·032 | 0·0289 | 0·0283 |
| | | 0·0283 | 0·285 |
| 0·365 | 0·360 to 0·370 | 0·361 | 0·363 |
| | | 0·363 | 0·362 |
| 2·88 | 2·83 to 2·93 | 2·90 | 2·89 |
| | | 2·88 | 2·89 |

These determinations were made on 0·5g. and 1·0g. samples with caustic soda solution in the cell. No result has been discarded. On low-carbon samples, containing 0·01 per cent. carbon, duplicate analyses agree within 0·001 per cent. and usually between 0·0002 or 0·0003 per cent.

# SHAFT RESILIENCE IN SERVO-MECHANISMS

## METHODS OF COMPENSATING ITS EFFECTS

*By David Morris*, D.SC., A.M.I.E.E.

The time-lags and resonances introduced by resilience in shafting can have a very serious effect upon the stability of servo-mechanisms, and the possibility of providing a rigid drive between motor and load is one of the first matters considered in designing the layout of a servo-system. The behaviour of a massive load driven by a motor through a resilient train of shafts and gears is very similar to that of the vibration absorber, which has previously been discussed in these columns.[1] The following treatment differs from the analyses of the vibration absorber only in that it is formulated explicitly to suit the convenience of the servo designer, and discusses the various means by which the servo-loop can be completed through the coupled-mass system.

### ASSUMPTIONS AND CONDITIONS

It is convenient to suppress the appearance of gear ratios in the analysis. This can be done by referring the whole system to the load side by multiplying the motor mass and other mechanical impedances by the squares of the appropriate gear ratios. The masses of the shafts and gears will be regarded as negligible. With respect to possible motions supplementary to a large operating velocity, friction at motor and load cannot be relied upon for beneficent damping, and will be neglected. Internal damping in the shafts is taken into account, and is assumed to be uniformly distributed. It will be assumed that there is no backlash. The rotational system can then be represented as in Fig. 1*a*, and a translational equivalent with lumped constants as in Fig. 1*b*. The inertia of the motor referred to the load side of the gearing is $m_1$, and the inertia of the load is $m_2$. We let $M = m_1 + m_2$. The torque developed in the motor, in response to signals applied to the opened servo loop, is represented by F. The torque in the shaft is represented by $f$. For checking stability, we shall assume that there is no extraneous torque on the load member.

Writing $p = \frac{d}{dt}$, (equals $j\omega$ for sinusoidal conditions):—

$$F - f = p^2 m_1 x \quad . \quad . \quad . \quad . \quad (1)$$

$$f = p^2 m_2 y = (x - y)(k + p c). \quad (2)$$

Adding:

$$F = p^2 (m_1 x + m_2 y) \quad . \quad . \quad . \quad (3a)$$

$$= p^2 M \left[\frac{m_1}{M} x + \frac{m_2}{M} y\right] = p^2 M z. \quad . \quad . \quad . \quad (3b)$$

Hence, if we take a point N, at distances $l_1$ and $l_2$ from the ends of the shaft, such that $l_1 m_1 = l_2 m_2$, the point N will have the same motion as it would have if the shaft were rigid. The point N will be called the "node," and its displacement will be represented by $z$, as in equation (3*b*).

The motion of each of the masses in terms of the motion of the node can be found from the second part of equation (2).

$$(k + p c) x = (k + p c + p^2 m_2) y. \quad (4)$$

$$\frac{x}{z} = \frac{M x}{m_1 x + m_2 y} = \frac{k M + p c M + p^2 m_2 M}{k M + p c M + p^2 m_1 m_2}. \quad . \quad . \quad . \quad (5)$$

This may be written:

$$\frac{x}{z} = \frac{1 + \frac{p T}{Q} + p^2 T^2 \left(\frac{M}{m_1}\right)}{1 + \frac{p T}{Q} + p^2 T^2}, \quad . \quad (6a)$$

where $T = \sqrt{\frac{m_1 m_2}{M k}}$ is the "time constant" for the motion of either mass about the node, and $Q = \frac{1}{c}\sqrt{\frac{m_1 m_2 k}{M}}$ is the "quality factor" for the same motion.[2]

If we set $\mu^2 = \frac{M}{m_1}$, equation (6*a*) may be written in the more symmetrical form :—

$$\frac{x}{z} = \frac{1 + \frac{p(\mu T)}{\mu Q} + p^2 (\mu T)^2}{1 + \frac{p T}{Q} + p^2 T^2}, \quad . \quad (6b)$$

where $(\mu T) = \sqrt{\frac{m_2}{k}}$ is the "time constant" and $(\mu Q) = \frac{(\sqrt{m_2 k})}{c}$ is the "quality factor" for the motion of the load about the motor.

Similarly,

$$\frac{y}{z} = \frac{1 + \frac{p T}{Q}}{1 + \frac{p T}{Q} + p^2 T^2}. \quad . \quad (7)$$

The open-loop response of the system can now be calculated by first assuming that the motor and load form a rigid system, which is a natural first step, and then applying the dynamic factors of equations (6) and (7) to determine the influence of resilience upon the motions of motor and load respectively.

The behaviour of all quantities can be represented on a vector diagram, as shown in Fig. 2. The shaft torque is chosen as reference, and the vectors are numbered in the order of their derivation. Vectors 2, 3 and 4 are derived in accordance with equation (2). Vector 2 corresponds to zero frequency, and serves to establish the diameter of the locus of $(x - y)$. Vector 5 is found by addition, and vectors 6 and 7 in accordance with equation (1). Vector 8 is found from equation (3), and terminates on the line joining the tips of vectors 4 and 5. The motor torque and the node displacement are in anti-phase.

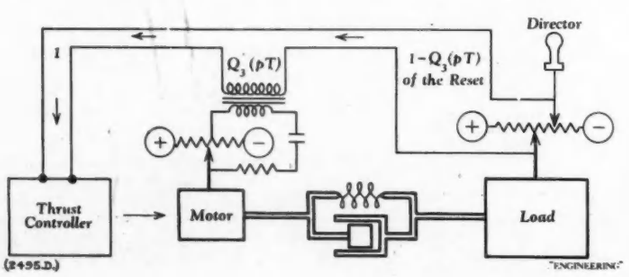



**Fig. 4 Translational representation of a system of "transient divided-reset."**

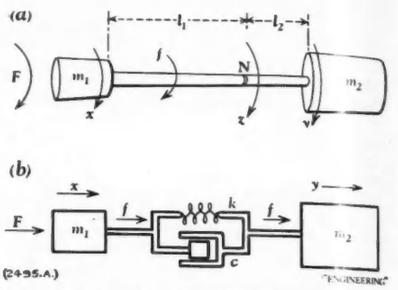



**Fig. 1 Rotational and translational representations of resiliently driven load.**

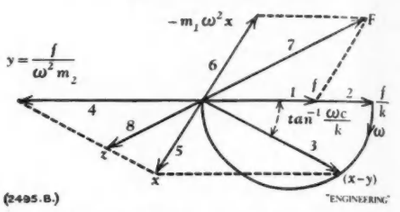



**Fig. 2 Vector diagram of torques and displacements.**

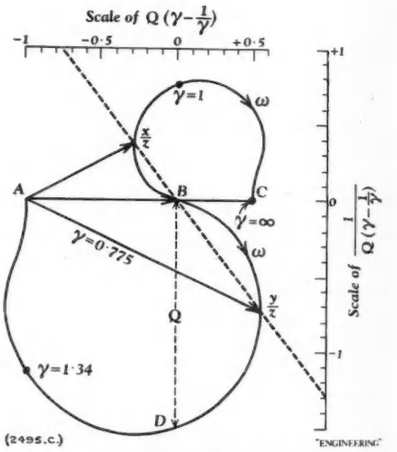



**Fig. 3 Loci of dynamic factors for motor and load.**

The behaviour of the dynamic factors $\frac{x}{z}$ and $\frac{y}{z}$ can be represented for all frequencies by the vector loci of Fig. 3, which are drawn for $Q = 1\frac{1}{2}$ as an example. The relationships are most easily studied by re-writing equations (6*a*) and (7) as follows:—

$$\frac{x}{z} = 1 + \frac{m_2}{m_1} Q_3(pT), \quad . \quad (8)$$

$$\frac{y}{z} = 1 - Q_3(pT), \quad . \quad . \quad (9)$$

where

$$Q_3(pT) = \frac{p^2 T^2}{1 + \frac{pT}{Q} + p^2 T^2}. \quad . \quad (10)$$

The function $Q_3(pT)$, together with the functions

$$Q_2(pT) = \frac{\frac{pT}{Q}}{1 + \frac{pT}{Q} + p^2 T^2}, \quad . \quad (11)$$

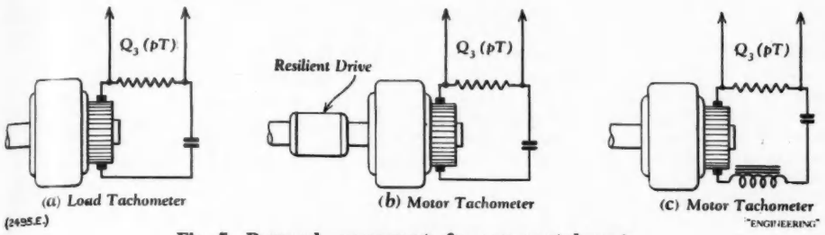



**Fig. 5 Proposed arrangements for compensated reset.**

$$Q_1(pT) = \frac{1}{1 + \frac{pT}{Q} + p^2T^2}, \quad . (12)$$

is of frequent occurrence in servo investigations. In the nomenclature given above, the subscript indicates the denominator term that is used as numerator.

In Fig. 3, $AB = 1$ and represents the phase of $z$, $BC = \frac{m_2}{m_1}$, and $BD = Q$. The responses at any relative frequency $\gamma = \omega T$ can be found by drawing a construction line through B to cut the scale of $Q\left(\gamma - \frac{1}{\gamma}\right)$ or of $\frac{1}{Q\left(\gamma - \frac{1}{\gamma}\right)}$ at the appropriate point.

## METHODS OF CLOSING THE SERVO LOOP

In a large class of servo-mechanisms, the position of the directing member as measured by a "transmitter" is compared with the position of the load member as measured by a "resetter," and the resulting error signal is used to control the torque developed in the motor. In general, the resetter should be coupled as closely as possible to the significant part of the load, because the control system cannot eliminate any errors that lie outside the servo loop. In terms of Fig. 1, direct coupling of the resetter to $m_2$ is to be desired. If resilience is present, however, the lag depicted by the factor $\frac{y}{z}$ in Fig. 3 often results in a degree of instability that renders the system useless. In such cases, a usable system can often be obtained by coupling the resetter, with suitable allowance for gear ratio, to the motor instead of to the load. The errors in the mechanical transmission are then outside the servo loop, but have to be accepted as alternative to the considerable reduction in loop gain that would be needed if resetting from the load were retained. Some load members, such as radar aerials, make their own measurement of position, and resetting is then inherently from the load. In such cases, the effect of resetting from the motor can be achieved by taking a continuous measurement of the deflection in the mechanical transmission and adding it as a "correction" to the radar signal.[3]

The phase-advance represented by the $\frac{x}{z}$ factor in Fig. 3 is in a general way favourable to stability, but it is not susceptible to much adjustment in design. Furthermore, for a mechanical transmission of high Q-factor, the increase in gain at resonance may be definitely obnoxious. Much simpler conditions are achieved by resetting from the node, in which case the stability considerations are the same as for a rigid system. Furthermore, all the mechanical errors except those between the node and load are taken inside the servo loop and their effect is therefore eliminated. In practice, the node is usually inaccessible, but the principle can be implemented by using "divided reset," resetters being coupled to both motor and load and their outputs being mixed in the appropriate proportion. This technique is well-established on a double basis, as it also mitigates the anti-stabilising action of backlash.[4]

In order to eliminate the remainder of the gear errors, while at the same time satisfying the requirements for stability, it has been proposed that the motor reset should be routed through a high-pass filter, so that it is operative only under transient conditions. This system is known as "transient divided reset," but no details appear to have been published.[5] The principle is illustrated diagrammatically in Fig. 4, the filter circuit being chosen to illustrate the application of the analysis given above. The above principles could be broadly implemented by many alternative high-pass filters, and a wide variety of different forms of resultant reset might be found to yield a stable control. However, great simplicity and flexibility in design would be achieved if the resultant reset could be made the same as that due to a rigid system, stabilisation then being effected by independently designed phase-advance or feedback. Inspection of equation (9) shows that this can be achieved if the function $Q_3(pT)$ can be developed from the system and added to the load reset. The output from the LRC circuit connected as shown in Fig. 4 is the product of a mechanical response as given in equation (6*b*), and an electrical response of the general form given in equation (10). If the electrical circuit is chosen so that

$$\sqrt{LC} = \sqrt{\frac{m_2}{k}} \quad \text{and} \quad \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{\sqrt{m_2 k}}{c},$$

the denominator of the electrical response cancels the numerator of the mechanical response, and the overall response is of the $Q_3(pT)$ form and has parameters of the desired values. In practice, the position-measuring system is usually operated by alternating current, with subsequent rectification. The routing of the motor reset through a high-pass filter may therefore be expected to lead to difficulties with electrical noise.

Fig. 5 suggests three other methods of obtaining a compensated reset, which are less subject to the noise difficulty. The tachometer is superior to the resetter as a source of compensation, firstly because the electrical signal is developed with one stage of differentiation already inherent, and secondly because the electrical signal does not require rectification. In Fig. 5*a*, the electrical circuit has a response $\frac{pRC}{(1 + pRC)}$, which can be designed to convert the response of equation (7) to the $Q_3(pT)$ response of equation (11). If allowance is made for an appropriate adjustment of gain, the inherent differentiation of the tachometer converts the $Q_2(pT)$ response to the $Q_3(pT)$ response of equation (10), which can be combined with the output from the load resetter to give a fully compensated reset.

If unfavourable gear ratio precludes the use of a load tachometer, the same electrical circuit can be fed from a tachometer resiliently coupled to the motor, as illustrated in Fig. 5*b*. With respect to a locked motor, the tachometer drive is made dynamically similar to that of the load, the appropriate parameters being ($\mu$ Q) and ($\mu$ T) of equation (6*b*). A resilient tachometer-drive is not amenable to easy adjustment, and Fig. 5*c* illustrates an alternative arrangement in which matching can be performed entirely on an electrical circuit. The LRC circuit has the same parameters as that of Fig. 4, but as the input is already differentiated the output is taken off the resistor.

It is important to notice that the circuits suggested above are meant to apply only to resilient systems in which backlash is entirely absent. The forms of instability produced by resilience and by backlash respectively are governed by entirely different laws. Ordinary divided-reset is designed to meet both sets of conditions; its success in both fields should not be taken as an indication that any technique of transient-divided-reset designed to combat resilience will also mitigate the effects of backlash.

## SUM-AND-DIFFERENCE TACHOMETER TECHNIQUE

The compensation of the reset does not, of course, render the complete system stable, as the lags in the filters and amplifiers have also to be compensated and, in addition, a definite damping action has to be provided. The damping can be provided by phase-advance (located for example in the thrust-controller of Fig. 4) or by supplementary feedback, often from a tachometer. If the tachometer is coupled either to the motor or to the load, the supplementary feedback is, of course, subject to the appropriate dynamic factor from

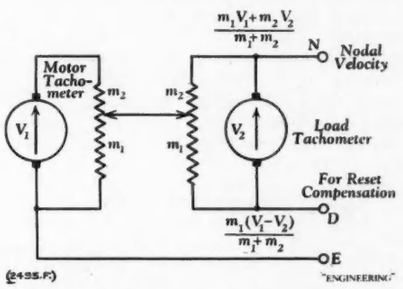



**Fig. 6 Extraction of sum and difference voltages.**

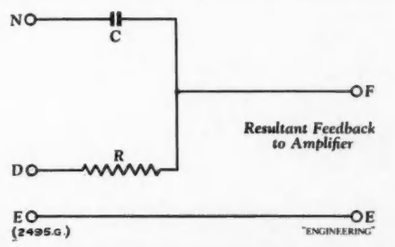



**Fig. 7 Example of a combined shaping and adding network.**

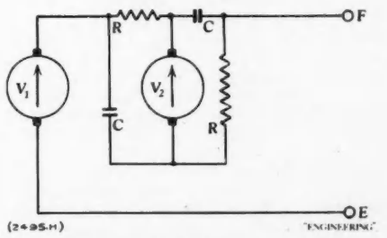



**Fig. 8 Circuit equivalent to a combination of the circuits in Figs. 6 and 7.**

Fig. 4. Great simplification in design would ensue if the tachometer for the supplementary feedback could be coupled to the node.

An advantageous arrangement is to use two tachometers, one coupled to the motor and the other to the load. An appropriate summation of the two outputs then provides a measure of the nodal velocity, and can be used as a source of feedback for the main damping. An appropriate difference of the two outputs gives a measure of the deflection velocity of the transmission, and if integrated takes the form $Q_3(pT)$ appropriate to reset compensation. Fig. 6 illustrates a circuit that combines the voltages appropriately, in accordance with equations (8) and (9), the ganged potentiometers being adjusted on site to suit the mass ratio. The tachometers are arranged to have equal terminal voltages when the system runs at a steady speed. If the difference voltage could be integrated perfectly, the reset compensation would be precisely the same as in a straightforward divided-reset system, and would reproduce any transmission errors between node and load. It is of interest to note that the resilience characteristic of the mechanical transmission does not have to be known if compensation is effected in this way. In practice, it is convenient to use approximate integration by means of an RC circuit, and in the choice of time-constant there is scope for making the integration good enough to provide stability, and yet not so precise as to reproduce the transmission errors under static conditions. The close relationship of this arrangement to the established divided-reset system provides a *prima facie* indication that it might mitigate the effects of backlash as well as of resilience.

It is desirable to combine the reset-compensation and the damping feedback to form a single feedback input to the amplifier. The method depends upon the damping characteristic required. As an example, Fig. 7 shows a mixing circuit which can be added to the circuit of Fig. 6, when the damping feedback is to be of the transient-velocity type, for the particular case in which the transientising time-constant is to have the same value as the integration time-constant.

Although the sum-and-difference concept is a convenient aid in visualising the properties of a two-tachometer system, and may even lead to useful circuit arrangements for empirical adjustment of the parameters of prototype control systems, the overall result may be regarded as the sum of individual contributions from each of the tachometers. When the desired parameters are known, therefore, simpler circuits may sometimes be used, in which the sum-and-difference aspect is no longer obvious. For example, when $m_1 = m_2$, the circuits of Figs. 6 and 7 may be replaced by the arrangement of Fig. 8, in which the motor tachometer feedback is used unmodified, and the load tachometer voltage is routed through an " all-pass network." A common feature of all these arrangements is that under steady speed conditions the motor feedback is negative and the load feedback is positive.

The concept of " compensation " is not to be applied too rigidly. In servo-mechanisms, the lags in filters and amplifiers are not usually compensated in the precise and comprehensive manner used for the " equalisation " of communication channels. In the same way, " shaft deflection compensation " is to be regarded as a useful conceptual tool, but should not be allowed to lead to unduly exact and cumbersome circuits, nor to limit the usefulness of stabilising circuits by restricting the parameters to the values required for exact compensation.

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# DISTORTION OF TURBINE SHAFTS AND ROTORS

## ELECTRICAL MEASURING EQUIPMENT

Two papers were presented at a joint meeting of the Steam Group of the Institution of Mechanical Engineers and the Supply Section of the Institution of Electrical Engineers held on Wednesday, November 24.

In the first of these, D. Antrich, H. W. B. Gardiner and R. K. Hilton described equipment, which had been developed to measure the temporary distortions that a turbine shaft might undergo during starting and sudden changes of load. This equipment consisted essentially of a steel disc, which was fitted coaxially to the part of the shaft overhanging the outer bearing. Round this disc were three pairs of iron-cored coils. Each pair formed the opposite arms of a bridge circuit, the other two arms of which were resistors. The vertical component of any movement of the disc with respect to the bearing housing, such as eccentric motion caused by the bending of the shaft, changed the air gaps differentially, and hence the inductance of the one pair of coils, thus affecting the balance of the bridge. Similarly, the bridge containing the second pair of coils was sensitive to any horizontal movement of the disc, while the third pair formed part of a bridge for measuring axial displacement.

It was necessary for the frequency of the power supply to the bridge circuits to be at least 20 times that of the motion to be measured. Since the eccentric motion was cyclic and of frequency equal to the speed of rotation, and the normal speed was 3,000 r.p.m., or 50 cycles per second, a power supply of about 1,000 cycles at 120 volts was chosen. This supply was obtained from an inductor alternator, since robustness and freedom from maintenance were desirable. The shaft motion was represented electrically at the output terminals of the bridge by a modulated carrier wave and this wave was translated into a form suitable for measurement by ratiometer instruments. Shaft eccentricity was indicated by a direct-current signal, which was a function of the depth of modulation. Motion in the axial direction was also detected by direct-current. The equipment included a cathode-ray oscillograph so that a trace of the locus of the shaft centre could be obtained and any abnormal disturbances investigated. In this way it was possible to indicate and record the vertical and horizontal eccentricities at the end of the shaft; the differential axial movement of the end of the shaft with respect to the casing; and the rotational speed of the shaft. In addition, the mean position of the shaft journal, with respect to its bearing and oil film, could be indicated in both the vertical and horizontal directions.

The equipment had been used during a number of factory trials under both normal and abnormal conditions and had been installed on the 60-MW turbo-alternators in the Uskmouth station.

### TURBOVISORY APPARATUS

In the second paper, which was entitled " The Electrical Measurement of Steam-Turbine Rotor Movements with Special Reference to the Operation and Design of Modern Power Plant," J. L. Ashworth, J. S. Hall and A. H. Gray said that the increased size of turbines and higher steam pressures and temperatures had led to the introduction of electrical turbovisory equipment. This equipment assisted rapid starting, during which the most important problem was the control of transverse rotor deflection. It gave the driver warning of this deflection in advance of the onset of noticeable vibration during running up, when the continued increase in speed might produce conditions which would be out of control by the time the senses became aware of them.

A variable-inductance method was the most satisfactory way of measuring both the differential axial expansion and the shaft deflection. The equipment consisted of detector magnets which were attached to the turbine casing on each side of the coupling and were connected to a source of alternating voltage at a frequency of 500 cycles. Each magnet thus formed a reactance in which the magnetic path was created by the core, the turbine shaft and two air gaps in series. As the shaft rotated the length of each air gap varied in amplitude according to the eccentricity and in periodicity according to the speed. The modulated current thus set up was passed through a transformer, rectifying valve and resistor, and then through a relatively high impedance low-pass filter, which eliminated the high-frequency components but left the low-frequency modulation due to eccentricity unaffected. The filter was followed by a cathode-follower in which the output appeared across a cathode load. The amplitude of the low-frequency voltage across this load showed the shaft eccentricity.

### ESTIMATION OF ECCENTRICITY

Examples were given of the eccentricity and differential-expansion charts that had been obtained on various types of plant with this equipment. Indication of eccentricity was specially useful since it showed the development of this condition before vibration became noticeable. The effect of eccentricity was to displace the centre of mass of the rotor from the axis of rotation and, while it was convenient to measure this on the shaft outside the steam space, the method caused difficulties in the interpretation of the readings. The first assumption must be that the deflection was in one diametral plane only and that it diminished to zero at the centre line of each journal, where the position in the bearing remained unchanged. Outside the journals the deflection was opposite in phase to that between them. The second assumption was that the curvature between the bearing centres was constant and that the portions at the ends were tangential to the bearing centre lines. It was then easy to obtain the relation between indicated eccentricity and radial displacement of the centre of mass.

At 3,000 r.p.m. the radial displacement of the centre of mass which would produce a centrifugal force equal to the weight of the rotor was about 0·004 in. This displacement could be produced by a relatively small temperature difference. If it were postulated that the centrifugal force must not exceed half the weight of the rotor the centre of mass deflection must not exceed 0·002 in. When turbovisory equipment was first installed efforts were made to keep well within this figure. Experience had, however, shown that even with an eccentricity reading of 0·005 in. there was no serious roughness.

Examples were also given of the use of the equipment in both operation and design ; and to check the speed and output, to indicate the difference between the steam and metal temperatures, to measure the expansion and to show the valve positions.

# MANCHESTER-SHEFFIELD RAILWAY ELECTRIFICATION

## OPERATING EXPERIENCE AND FUTURE TRENDS

The conversion to electric traction of the lines of British Railways from Manchester to Sheffield and to Wath was described in a paper read before the Institution of Electrical Engineers by Mr. J. A. Broughall and Mr. K. J. Cook on Thursday, December 2. After analysing the nature of the traffic, descriptions were given of the fixed equipment and rolling stock, details of which have already appeared in ENGINEERING.* The operating experiences obtained on the line to Wath, on which traffic has been electrically hauled since February, 1952, were recorded and the question of possible future extensions and trends in design were discussed. We summarise these sections of the paper below.

### EXPERIENCE ON WATH BRANCH

The short length of 18 miles comprising the Wath branch provided the first piece of concentrated freight haulage by electric traction in the British Isles and was, said the authors, crowded with testing points. It might safely be said that physical and technical difficulties were likely to be much less in practically all other parts of the country.

On one occasion a particularly violent thunderstorm had caused more than 40 strikes on the electricity supply network and had affected three locomotives in service. Trouble from icing had been negligible and generally any interruptions due to wintry conditions had been caused by snow in the points.

Adjustment of 5 ft. had been allowed in the design of the contact-line supports in areas liable to subsidence, and at one location this had been completely absorbed. Further provision in such cases entailed building up foundations and lifting the supporting structures to a height which would enable the girder to revert to a lower position on the uprights.

The supervisory control over the system from Penistone had functioned satisfactorily, and the few cases of failure had been due to dust on contacts in the substations. In no case had any interruption of supply resulted. Two failures of rectifiers due to leakage through the anode ignition seals had been dealt with by redesigning the seals. Some trouble had been met in the cable joints owing to mechanical stress caused by movement of the cables. Examination of joints by $\gamma$-rays had been extensively used in investigating the causes.

### ROLLING STOCK

The heavy mineral and freight trains were composed mainly of loose-coupled unbraked stock, and drawgear limitations and other circumstances necessitated one locomotive on double-engine loads being at the rear. Under the worst conditions, adhesion had been found to be as low as 0·17. The assisting engine at the rear was the more likely to slip and, as it did so, overload was thrown on to the train engine. One cause arose from wet small coal, drippings from which fell on to the track, making the conditions worse for the rear engine. A large quantity of this traffic was carried over the line, and such wagons were the most heavily loaded rolling stock.

This slipping, and also the difficulty of synchronising the movement from series to parallel working between the two locomotives, had thrown considerable strain on the bogie centre pivots. Probably the effects of inertia from the bodies of the Bo + Bo locomotives were underestimated, and it had been found desirable to replace the original cast-steel pivots by forgings, reducing the leverage by shortening the pivot and interposing a ¾-in. plate between it and the understructure of the body.

Initially, the extremely dirty condition of the atmosphere caused difficulties with air filtration. The contamination arose from three main sources: the sooty and smoke-laden atmosphere, cast-iron dust from brake shoes, and the exhaust from the traction-motor blowers stirring up carbonaceous deposit which had accumulated on the track. The filters in the body sides became partially clogged in the course of a few days and the air found its way through all possible inlets and crevices, partly through the driving cabs, making them cold and draughty. Negative pressure in the high-voltage and resistor compartments led to deposition of dust, some of it metallic, and extensive blowing out and cleaning was necessary. The solution had been to reduce the degree of filtration and to divert a direct air-stream from the blowers into the high-voltage compartment in order to put this at a pressure slightly above atmosphere and thereby restrict the ingress of totally unfiltered air.

Standard working arrangements utilised both pantographs—to reduce the collection per pantograph. This had been beneficial in many cases where it was not possible to adjust for subsidence day by day, in sidings not frequently used, where contact wires became contaminated with smoke and particularly for supplying the full steam-heating load when locomotives were stationary. Both lac and grease had been used for pantograph contact-wire lubrication, and after much experiment it had been decided to adopt an appropriate grease.

Tyre wear was naturally heavy and tyres had required re-turning at 35,000 to 40,000 miles. Work of this kind was carried out at Gorton Locomotive Works, as also would be "casual" repairs of an extensive nature and all long-period overhauls. Day-to-day servicing was catered for on a systematic basis at the electric depots on time periods of 5, 30 and 60 days. The short-period servicing required 2 hours and was carried out between turns on a round-the-clock basis. The 30- or 60-day servicing requiring 8 hours was completed in the normal day shift, and the locomotive was available for a turn commencing after 5 p.m. Availability had been of the order of 96 per cent. It had not yet been possible to obtain firm figures of availability, including works overhauls, since the tyre turning had so far been arranged in conjunction with modifications, but with interchange of bogies it was anticipated that a high availability would be maintained.

The heavy traffic on the initial stage of electrification had been satisfactorily handled and the encroachment into the week-end to clear each week's loadings had been greatly reduced. Nevertheless the full traffic potentialities could not be realised while steam-hauled freight trains from Sheffield and Barnsley were sandwiched between electric trains so that the average speed tended to be reduced to that of steam operation. This position was somewhat eased by the opening of the new Woodhead tunnel and by the introduction of full electrified operation from Manchester as far as Penistone, but it awaited the final extension to Rotherwood Exchange sidings, east of Sheffield, in order to realise the full traffic possibilities.

### POSSIBLE FUTURE EXTENSIONS

The present scheme was of too isolated a nature to permit the full benefits of electrification being achieved. In particular, it was not large enough to allow the closing of any motive-power depot and most trains suffered a change of motive power from steam to electric at Rotherwood or Wath, and vice versa in the Manchester yards. Investigation was now being made of the most efficient way of extending the electrification of the line.

The cost of electrifying the lines from the collieries and marshalling yards south of the present termination at Rotherwood seemed likely to be appreciably less proportionately than that of the work completed. These lines were relatively simple in pattern and would permit the use of newer less costly techniques developed since the present scheme was planned. Development of this area would naturally lead to consideration of extending the electrification eastwards to Lincoln and Whitemoor and southwards down the old Great Central line, by which freight traffic could pass expeditiously to the South Western via Woodford and Banbury. On the western side, the flow of traffic was much more diverse, and it would seem that the most likely immediate development was of a suburban character based on completing the present electrification to Manchester Central and electrifying the lines to Hayfield and Rosehill.

### FUTURE DESIGN TRENDS

As nearly 20 years had elapsed between the inception of this scheme and its completion, it was not surprising that new knowledge had become available and that fashion had changed, so differences in equipment would be considerable if these extensions proceeded.

As regards power supply for instance, the tendency would be to take local supplies at the substations and thus to avoid costly railway-owned high-voltage feeders. If possible, supplies would be taken at 11 kV. If 33 kV-cables were essential, for example in such areas as the Pennine crossing where no other use for electricity existed, they would be of the oil-filled type suitably served with polyvinyl chloride or other non-permeable material, buried direct, if the terrain allowed, or continuously supported in concrete troughs or asbestos-cement pipes.

The high-voltage switchgear would be of the indoor metalclad compound-filled type with minimum oil circuit-breakers and the rectifiers of the pumpless fan-cooled type in glass or steel containers, unless the mercury-arc rectifier was superseded. The supervising system would probably give direct control and indication of each switch from a miniature diagram.

If, as seemed probable, present substation and track-paralleling hut spacings were maintained, the cross section of the overhead conductors would be reduced, span lengths increased and the weight of structures decreased. Single cap-and-pin insulators would be used with non-ferrous fittings and registration from the span wires. Wherever possible foundations would be mechanically excavated, using a truck-mounted auger to produce small deep cylindrical foundations for the structures.

### LOCOMOTIVE DESIGNS

New designs were in preparation for standard locomotives. These would probably include a central cab, multiple-unit control, air-blown resistors with vernier notching and the maximum use of vertical-shaft rotary drives for the auxiliaries, so as to economise floor space. It seemed probable that Bo-Bo and Co-Co locomotives would satisfy all except a few classes of train and might be arranged with double-reduction gears to decrease the motor weight. Passenger trains would increasingly be of the high-speed, lightweight, multiple-unit type allowing the full benefits of electrification to be available to passengers and to railway operating and motive power staff, and permitting locomotives to be designed for the freight services for which they were most suitable without the complications introduced by attempting to make a mixed-traffic type. For instance, boilers would be unnecessary. It was probable that increased attention would be paid to camshaft controllers to economise space. In general, the object would be to reap the benefits of improved manufacturing techniques, which should allow practically unlimited life on the track without servicing.

* See ENGINEERING, vol. 169, page 205 (1950); vol. 173, pages 164, 180 and 321 (1952); and pages 20 and 413 in the current volume (July 2 and September 24, 1954).

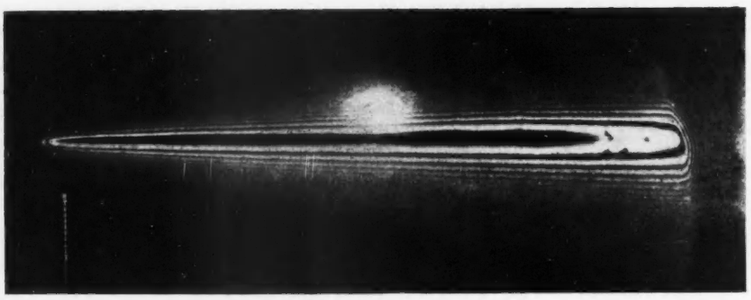


Fig. 1 Interferogram of indentor with long straight flank "lined up" × 120.

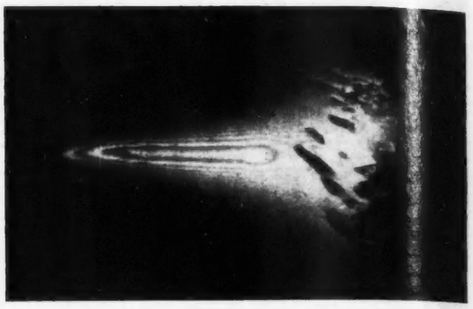


Fig. 2 Interferogram of indentor with shorter convex flank "lined up" × 120.

# DIAMOND INDENTORS FOR ROCKWELL-HARDNESS TESTING*

## FURTHER DEVELOPMENTS IN THEIR PRECISION MEASUREMENT

*By F. R. Tolmon and Joyce F. Hall*

*In a previous paper,† an account was given of methods developed at the National Physical Laboratory for the measurement of the angle of the cone and the radius of the tip of diamond indentors used in Rockwell-hardness tests. Some further developments have since been made at the Laboratory and these are described in the present paper, which includes also a brief statement of the experience gained in the inspection of indentors during the past few years.*

### CONE ANGLE

The method devised for measuring the angle of the cone has proved capable of giving very high accuracy. In this method, the indentor is mounted on an optical rotary table and settings are made by bringing each flank of an axial section in turn parallel with a semi-reflecting proof plane and viewing the interference fringes so formed in a microscope of magnification × 50 mounted with its axis horizontal. The rotation of the indentor about its axis enables measurements to be made in as many azimuths as is desired. Figs. 1 and 2 illustrate, at a magnification of approximately 120 times, the view as seen through the eyepiece of the interference microscope of the angle-measuring apparatus. Both figures show indentors in the "lined-up" (fiducial) position. It will be appreciated that "lining-up" is easily done when the indentor has a long, straight flank. The indentor illustrated in Fig. 1 is approximately 0·038 in. (0·97 mm.) long and straight to well within 0·00001 in. (0·00025 mm.) over the major portion of the flank. Fig. 2, however, shows an indentor which is more difficult to measure since the flanks are both short and convex. This indentor is approximately 0·017 in. (0·43 mm.) long and convex by approximately 0·00003 in. (0·00076 mm.).

The accuracy with which the cone angle can be determined depends principally on the length and straightness of the flanks. For an indentor such as that illustrated in Fig. 1, an accuracy within ± ¼ minute of arc can be attained for the mean cone angle.

The projection of the tip of the indentor at a magnification of 1,000 times and a comparison of the image with an accurate projection drawing of the nominal profile to the same scale has proved useful. It enables the departures of the profile from nominal to be determined to the order of 0·00005 in. (0·0012 mm.) measured at the indentor.

### BLENDING

During the projection of the indentor and likewise during the measurement of the cone angle, some appreciation may be gained of the blending of the radius with the flank, i.e., whether the spherical and conical surfaces are truly tangential. It was felt, however, that a more critical method of examining the blending was needed. A considerable improvement was realised when interferograms and photographs of blendings were successfully obtained on a micro-interferometer at a magnification of × 350. The interferograms are, in effect, contour maps having a contour interval, i.e., the spacing between consecutive fringes, of about 0·00001 in. (0·00025 mm.). Typical indentor blendings are shown in the interferograms Figs. 3, 4 and 5, all at a magnification of 600 times. Fig. 3 shows an almost perfect blending, while Figs. 4 and 5 show other degrees of blending.

Fig. 6 illustrates (also at 600 magnification) a very poor blending of an indentor, and in addition, there appear to be small cracks present on the reasonably-well finished flank of this indentor. It will also be seen that the surface texture of the tip is poor.

In another new technique developed to investigate further the poor blending already illlustrated in Fig. 5, the indentor is viewed in a microscope, with its axis co-axial with that of the microscope. The instrument, however, is not focused on the tip of the indentor, but on the junction of the spherical tip with the cone. Fig. 7 shows a typical photograph, at 400 magnification, when the blending is poor; if a well blended indentor is examined in this manner the blend is, of course, quite invisible.

In Fig. 7 it will be observed that the blending is far from circular. This might be because the tip is not spherical or because the cross section of the cone is not a circle. As other evidence pointed to the latter defect, an attempt was made to detect it by the use of the "Talyrond" roundness machine. The initial trials with the "Talyrond" indicated a lack of circularity of the cone, but only after a special design of stylus had been made was it possible to place reliance on the results obtained. The new stylus was constructed so that it contacted the cone normal to the flank, but the plane of measurement was arranged in such a manner as to be perpendicular to the axis of the indentor. Tracings of typical "Talyrond" charts taken on the flanks of indentors are shown in Figs. 8 and 9. Both charts have a radial magnification of about 1,170 times.

Care must be exercised when interpreting the "Talyrond" charts on account of the distortion due to the high radial magnification. In the examples shown, the departure from circularity is 0·0004 in. (0·01 mm.) and 0·008 in. (0·02 mm.) respectively, the departure being defined as the difference in diameter of two imaginary co-planar concentric circles such that the annular space between them would just contain the profile of the surface under test. In tests on a number of indentors, considerable variation in circularity was found, in the best case the error in circularity was 0·0002 in. (0·005 mm.) in the worst so far examined 0·0008 in. (0·02 mm.).

Fig. 3 Interferogram of almost perfect blending × 600.

Fig. 4 Interferogram of less perfect blending × 600.

* Communication from the Metrology Division of the National Physical Laboratory. Abridged.

† By F. R. Tolmon and Jill G. Wood. See ENGINEERING, vol. 172, page 89 (1951).

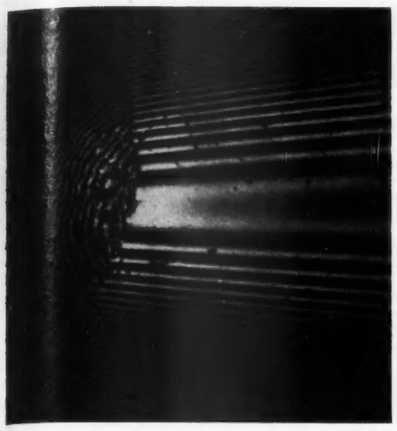


Fig. 5 Interferogram of poor blending × 600.

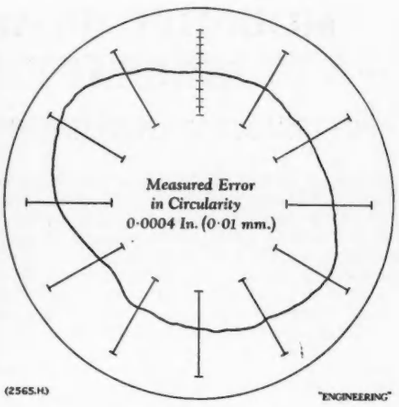



Fig. 8

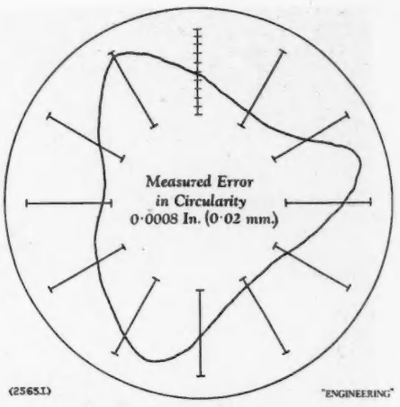



Fig. 9

Figs. 8 and 9 Tracing of Talyrond charts at radial magnifications of × 1,170.

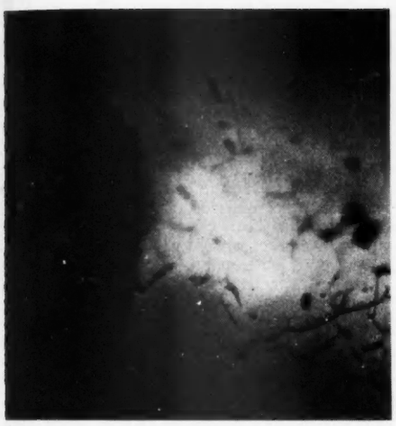


Fig. 6 Interferogram of very poor blending × 600.

Fig. 10. Interferogram of tip of indentor × 800.

Fig. 11 Interferogram of "tip" of indentation × 800.

Fig. 7 Indentor when blending is poor × 400.

Fig. 12 Interferogram of blending of indentor × 650.

Fig. 13 Interferogram of "blending" of indentation × 650.

## FORM OF INDENTATIONS PRODUCED

In order to get some assessment of the quality of surface finish and the accuracy of blending desirable in indentors, a knowledge of the behaviour of the indentors in producing indentations is needed. Several indentors were therefore chosen and interferograms of their tips and of the blendings obtained. Each indentor was then used to carry out a hardness test on a suitable hardened and lapped steel specimen, and interferograms and photographs of the indentations produced were made.

A typical interferogram and photograph of an indentor and an indentation are reproduced in Figs. 10 and 11. This shows the tip of the indentor and the corresponding "tip" of the indentation. The interferograms in Figs. 12 and 13 and the photographs in Figs. 14 and 15 show the blending both for the indentors and the corresponding indentations, the indentor of Fig. 14 being the same as that of Fig. 12. It will be seen that the form of the indentor is faithfully reproduced in its indentation in the region of the tip and the blending. The bell-mouthing of the indentation can be clearly seen. This effect is due to the build-up of material around the edge of the indentation and to the varying

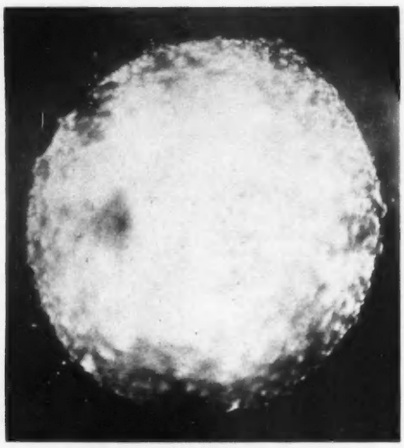


Fig. 14 Blending of indentor × 375.

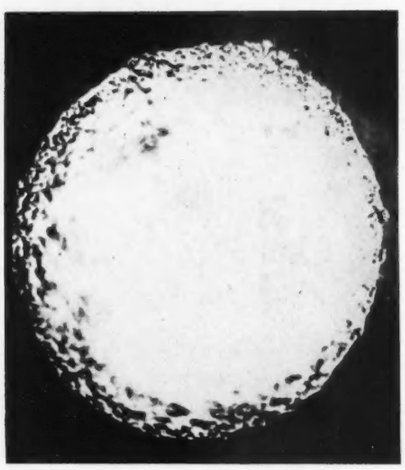


Fig. 15 " Blending " of indentation × 400.

proportion of plastic to elastic deformation which occurs between the " tip " of the indentation and the original surface of the specimen.

## CONCLUSION

The measuring techniques which have been described are in constant use in the Laboratory for examining indentors used in investigations into the measurement of hardness by the Rockwell principle. The techniques proved to be adequate. Many indentors have been examined; very few have been found to possess the prescribed form. When one recalls the properties of the diamond this is not surprising, and it is only too clear that to make the ideal indentor calls for skill of a very high order.

The authors desire to acknowledge the comments and suggestions they received from their colleagues in the Metrology Division, National Physical Laboratory.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this paper is published by permission of the Director of the Laboratory.

*Editor's note:*—For purposes of reproduction the original magnifications of the illustrations have had to be reduced. Figs. 1 and 2 from × 150 to × 120; Figs. 3, 4, 5 and 6 from ×1,000 to ×600; Fig. 7 from ×1,000 to ×400 Figs. 8 and 9 from × 2,000 to × 1,170; Figs. 10 and 11 from × 1,000 to × 800; Figs. 12 and 13 from × 1,000 to × 650; Fig. 14 from × 1,000 to × 375 and Fig. 15 from × 1,000 to × 400

# MOULDED PLASTIC TOOLS FOR AIRCRAFT PRODUCTION

## PRECISION TOOLS MADE BY SEMI-SKILLED LABOUR

As reported in last week's issue of ENGINEERING (page 726), the possibilities of jigs, fixtures and press tools made of plastics have recently been under discussion by sheet-metal users. It may therefore be of interest to refer to the methods of the Société Nationale de Constructions Aéronautiques du Sud-Ouest, 105, Av. Raymond Poincaré, Paris (16e), who have issued details of the technique they have developed for producing plastic and reinforced concrete tools for aircraft manufacture. This technique, they claim, has enabled precision tools to be used in constructing prototype or short-run aircraft where hitherto improvised tools had been used. It also greatly accelerates the tooling-up for quantity production, results in reduced machining operations, and allows the use of semi-skilled workers for tool making.

### MASTER MODEL

The principle of making plastic tools depends on making a master model representing (with very close tolerances) the shape of the assembly to be fabricated (inside of aircraft skin). This master model consists of a stiff framework, trunnion-mounted in the case of symmetrical sections, which receives metal templates taken from the loftings of the aircraft. These are the only operations essentially identical with those involved in making metal tools.

This combination of templates and rigid framework next receives modelling plaster which is applied with a flexible steel rule, by fairing in plaster between templates and using the templates as fairing guides to develop the contour. After the plaster master model has dried, the model surface is protected with a plastic sealer. Reference and station lines are then traced on to the master model, these lines representing the various structural elements (under the skin) of the aircraft.

The master model is the main standard of tool fabrication, and it provides the means of obtaining (solely by moulding) tooling for prototype parts and assembly fixtures, which are the prerequisites of aircraft fabrications. The mould, a faithful reproduction in reverse of the profile of the master model, is obtained with a mixture of cement and plaster, reinforced with hemp, or with glass-cloth reinforced plastic. The mould is attached, by means of small plaster and hemp ties, to a metal welded structure.

### DRAW DIES

Draw dies are made with Rezolin, a liquid thermosetting phenolic resin remarkable in that no shrinkage accompanies the hardening. Its ease and variety of use permit the making, in only a few weeks and with equipment consisting merely of an oven and a mixer, of a complete large-size die. This is possible because the tool is ready to put into use as it comes from the mould.

The precision of contour, the resistance of its surface finish to use and time, and the ease of repair or correction make this product particularly suitable for hydraulic press dies or double and single action dies, these being mounted either on hydraulic or on mechanical presses. It is equally suitable for narrow types, whether in length or height, of stretch dies. Lastly, the product serves to make shaping tools for plastic parts such as turrets and cockpit canopies.

The making of these tools begins with taking a plaster mould from the master model or from an already existing tool. To assure the mould holds its shape, it is reinforced with a structure of welded tubes. After the mould, or female impression, has been dried and coated, the plastic is poured into it at room temperature. It is allowed to harden partially at room temperature and then transferred to an oven at moderate temperature. The tool is ready for use as it comes from the mould, about 40 hours after casting.

For tools to be used on mechanical presses, where greater shock resistance is required, a core of phenolic Rezolin plastic is reinforced with a shell about ¼ in. thick of a Rezolin plastic of the epoxy type. The wearability of tools made in this manner is such that their use is foreseen for shock tools, such as drop hammer dies.

### DRILLING FIXTURES AND ROUTING TOOLS

Drilling fixtures are obtained by taking moulds from the master model or its counterpart. The basic material is a glass-epoxy laminate. Hardening is accomplished at room temperature and the tool is unmoulded about five hours after lay-up.

Routing tools consist of a male element (fixture) which holds the sheet to be routed, and a jig; the two elements and sheet are positioned and clamped by conventional means. The fixture is composed of a glass-cloth laminate moulded against a female plaster, and tied to a welded tubular structure by glass-cloth laminated ties. The jig consists of a preformed mild-steel grill which has been cleaned along the general routing contour where glass-cloth laminated strips are to be bonded. This jig is clamped on the fixture part of the tool. Hardening occurs in a manner similar to that previously described for laminated tools.

### FLANGING TOOLS

The process of making flanging tools was worked out so as to allow for the possibility of a hand-finishing operation. Their mechanical properties and wear resistance are such that, without major repairs, they stand up under the usual production series for aircraft parts. These tools are suitable for hydraulic-press work and hammer forms.

A plaster mould is taken from the master model; into this mould is cast a polyester resin charged with a metallic powder; this operation is followed by a lay-up of glass-cloth and polyester resin. Finally, a previously polymerised block of glass cloth and polyester laminate, roughly cut to contour, is applied to the lay-up with pressure, this block acting as a core and reinforcing element.

Hardening occurs firstly at room temperature for four hours and secondly by submitting the tool to 90 deg. F. for 30 minutes. In cases where flanging occurs in two opposite directions, the reverse-shape tool may be fabricated according to the above method.

### ASSEMBLY AND CHECKING FIXTURES

Male tools are cast and/or moulded directly against female moulds taken from the master model, and on which, with the aid of a special coating, a tracing is made to facilitate positioning of the various elements. Female assembly fixtures, used for the assembly of prototype parts, are moulded directly against the master model. These tools consist of a glass-epoxy laminated shell fastened to a rigid metal frame by means of plastic and glass-cloth strips.

Concrete stretching tools are used for stretching metal sheets into shapes other than deep and narrow ones, where their resistance would not be sufficient. They are used in particular for shaping aircraft skins and doublers. The tools are cast directly into a female mould taken from the master model, the casting of concrete being done on a vibrating bench. The tools are unmoulded 48 hours after casting and can be put into use 10 days later.

# THE RESEARCH ASSOCIATION OF BRITISH RUBBER MANUFACTURERS

## NEW LABORATORIES AT SHAWBURY

The new laboratories and headquarters of the Research Association of British Rubber Manufacturers at Shawbury, Shropshire, which were opened by H.R.H. the Duke of Edinburgh on November 23, were acquired in 1952 to replace former premises at Croydon. These premises had become inadequate for the growing volume of work undertaken by the Association. The Research Association is one of about forty co-operative research bodies which operate under a scheme introduced by the Department of Scientific and Industrial Research in 1918; under this scheme the D.S.I.R. makes financial grants to such associations provided that the industry concerned also gives adequate financial support.

The Research Association of British Rubber Manufacturers was founded in 1919 on a small scale, with a staff of three and 15 member firms. Growth was steady and in 1922 accommodation was acquired at Croydon which proved adequate for several years, but by 1939 the Croydon premises were overcrowded. Nothing could be done to increase the facilities until after the war, and it was not until 1952 that the Shawbury premises were purchased. In moving to Shropshire the Association took into account the fact that the rubber industry is centred in the Midlands rather than in the London area, and the Shawbury site is accessible from all the main centres of rubber manufacture. The whole of the work of the Research Association is now concentrated at Shawbury, in a large block of red brick buildings of pleasing appearance and with ample accommodation for a staff of over 90, who work under the direction of Dr. J. R. Scott, M.Sc., F.R.I.C., F.Inst.P., F.I.R.I., director of research of the Association.

The objects of the Association are to undertake research on the materials and processes of rubber manufacture; to help member firms (of which there are now more than 300) in technical matters; to maintain a library and information service; and to finance fundamental research in the Universities.

### LIBRARY AND INFORMATION SERVICE

The Association maintains at Shawbury what is claimed to be the world's largest library and classified file on rubber and rubber-like plastics. About 70,000 books and pamphlets, 8,000 volumes of journals and 750,000 index cards are filed, and from these sources, which are continuously augmented from all over the world, the Association provides a regular information service for members. A monthly Bulletin is sent to all members, and in addition abstracts dealing with scientific and technical information, a patents and trade marks review, and an economic review are circulated monthly. A supplement to the patents and trade marks review is sent out fortnightly. There is also a Press cuttings review, which abstracts articles on the use of rubber. From the library sources the Association also provides answers to specific problems and questions from member firms on all aspects of rubber science, technology and economics.

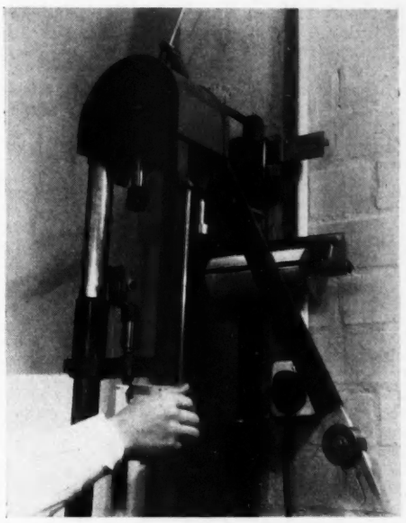
### LABORATORIES

The premises at Shawbury are provided with extensive facilities for chemical and physical examination of rubber and raw materials. The chemical laboratories are in two blocks, the first of which, containing four rooms, is devoted to analysis. The second block, of three rooms, is engaged on fundamental research. The laboratories are well equipped, with separate rooms for microchemistry, balances, and routine and special analysis. Physical laboratories adjoin the chemical blocks.

The technological laboratories are equipped for studying the technical development of the results of chemical and physical research, for studying new raw materials and for the development of new testing methods. They are also used for the investigation of specific technical problems submitted by individual member firms.

The equipment available includes a mill-room for making experimental rubbers, a mechanical testing laboratory, rooms for special investigations of textile problems, and similar facilities for dealing with test procedures. There is also a fully-equipped maintenance workshop. This workshop, which is provided with a range of machine tools, welding and sheet-metal working machinery, undertakes the construction of new apparatus and instruments and the modification of purchased equipment as required, in addition to maintaining the plant throughout the laboratories.

The mill-room is designed for the manufacture of experimental rubbers of all kinds, and the machinery installed includes a Banbury mixer; a David Bridge mixer, with a new type of safety guard developed by the Leyland and Birmingham Rubber Company, Limited; a Berstorff calender; a rubber extruder; a Francis Shaw mixer; and a Hollings and Guest vulcanising press. Rubbers can thus be made and worked throughout on a small scale which reproduces in every way normal factory procedure. Experimental work on machine design and safety guarding can also be carried out. One of the mills is shown in the left-hand illustration below.



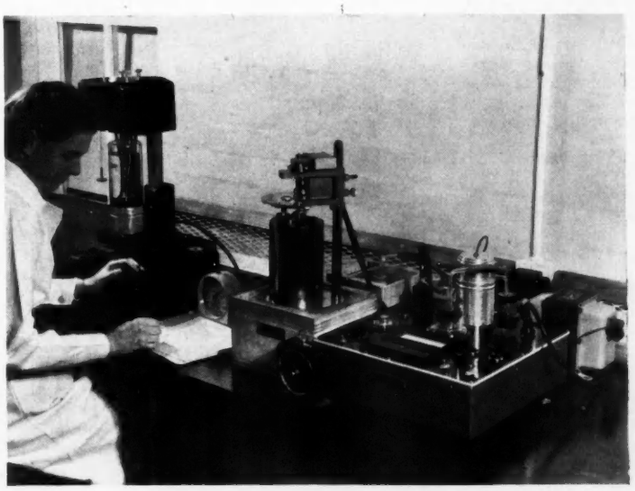
Testing rubber with a Hounsfield tensometer.

A large laboratory is provided for carrying out mechanical tests of all kinds. The equipment includes a Schopper tensile testing machine, a Hounsfield tensometer which is shown in the illustration above, a Goodrich flexometer, a Bureau of Standards strain tester, a Du Pont and an Akron-Croydon abrasion tester, a Macklow-Smith and an Avery tensile tester, and a Taber abraser. There is also a L'Homme and Argy direct-reading specific gravity balance. Equipment for the investigation of special problems includes a Butterworth and Dickinson power loom, which is housed in a separate room and can be used to produce the many different types of fabric used in conjunction with rubber.

### PROBLEMS INVESTIGATED

At the time of the official opening a number of exhibits had been arranged to show some of the problems investigated by the Association, and

Mixing rubber in an experimental mill.



Testing rubbers at low temperatures.

the results achieved, together with some of the methods of investigation used. Among the latter are two modern techniques for analysis. For the analysis of vulcanised rubber the spectrometer is used. The constituent substances are first removed from the rubber by solvents and the resulting solution is poured on to a column of adsorbent material, and the constituents identified by examination with a spectrometer. For the rapid identification of synthetic and natural rubbers there is a swelling test. A piece of rubber is suspended in a suitable liquid, and by measuring the amount of swelling it can be identified.

Another problem which has received the attention of the Association is that of using textile fabrics and cords as a part of rubber products. Cotton causes no difficulty, but the rubber will not adhere to the synthetic textiles such as rayon, nylon and Terylene. The Research Association has developed a method of giving the textile material a "hairy" surface by brushing or abrading, or by incorporating short staple fibres into the weave. This development has proved entirely successful.

The electrical insulating properties of rubber, which are so valuable in many instances, can be a definite disadvantage and a source of danger in certain applications. The Association has contributed important work on the problem of producing an anti-static or "conductive" rubber, and has been largely responsible for developing test methods to ensure that anti-static rubber will perform as required. Examples of rubber products from this material include hospital equipment, tyres and conveyor belting,

### AGEING OF RUBBER

The principal causes of ageing in rubber, with consequent hardening and cracking, are atmospheric oxidation and ozone attack. Atmospheric oxidation is greatly aggravated by traces of certain "poisons," notably copper compounds. The Research Association has investigated this problem, and has produced a material which it has called "RA-plex 1," which combines with copper and reduces the ageing effect. Ozone, which is present in traces in the air, causes cracking. For studying this problem the Association has developed a special ozone testing cabinet. Other equipment and tests have been devised to study the resistance of rubber to sunlight and other harmful influences. With the aid of these tests and equipment it has been possible to develop means of increasing the durability of rubber.

**Routing a component from the solid. A tungsten-carbide tool is used, with a template guide, to sink pockets in the material in a series of shallow cuts.**

# HIGH-SPEED MACHINING OF NON-FERROUS ALLOYS

## RADIAL-ARM ROUTER MANUALLY CONTROLLED

The new heavy-duty machine added to the range of routers made by Wadkin, Limited, Green-lane Works, Leicester, is capable of profiling, milling and routing operations which have hitherto been beyond the capacity of machines of this type. It is shown in the illustration opposite. The new model will machine practically all the aluminium alloys, in cast, forged or rolled condition, brass, zinc and lead. Certain coppers and many plastics can also be dealt with at high speed and to close limits of accuracy by this router. Under suitable conditions it can be used for cutting out aluminium alloy plates up to 1 in. thick from profile plates or templates, and for finish-profiling similar material up to 3 in. thick after roughing-out by band saw. On such profiling work up to $\frac{1}{8}$ in. of material can be removed at each pass. Face-milling with cutters up to 5½ in. in diameter is also possible.

The basic machine consists of the central column carrying the radial arm, the work head and a single-unit frequency changer controlling the current to the two-speed motor. This frequency changer is shown in the illustration at the back of the machine, but it can, of course, be installed in any convenient position, leaving the space at the rear of the machine free for a base plate or work table as required. To the basic machine are added powered work tables or base plates or any combination of these items according to the requirements of the work being done.

The machine is designed for easy manual operation and, having great rigidity and high cutting speeds, produces a smooth finish. Cutting stresses are negligible, and only light clamping of the work is necessary. Fixtures can thus be of simple design, there is no distortion of light-section components, and the time taken to load and unload work can be reduced considerably.

### ROUTER HEAD OF UNIT CONSTRUCTION

The work-head of the machine is of simple design, consisting of a high-speed squirrel-cage motor mounted on V-slides with a maximum rise and fall of 12 in. The cutter spindle, which is of nickel-chromium-molybdenum steel, and keyed direct to the rotor, is carried in ball bearings, with oil-mist lubrication. The spindle nose is taper-bored to suit a standard range of cutters and collets, and is hard chromium plated in the bore to reduce wear. Large cutters are drawn into the taper by a draw-bolt extending right through the spindle, and small cutters are carried in collets retained in position by the same means. The draw-bolt is easily accessible from the top of the motor unit, and cutters can be changed in a few seconds. A spindle lock is provided for use when changing cutters. The stator frame is of aluminium, cored to allow air to be drawn over the stator by a fan mounted at the top of the spindle.

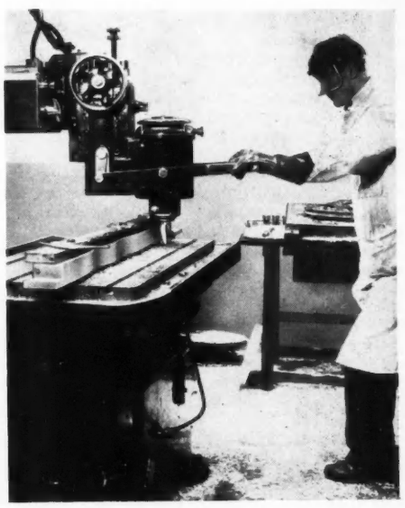
Two speeds are available, the selection being made from a two-way switch mounted at the side of the router head. This control point also incorporates stop and start push-buttons. The normal head-motor develops 5 h.p. at 18,000 r.p.m. and 4 h.p. at 12,000 r.p.m., but a larger one can be supplied if required, for outputs of 12½ h.p. at 18,000 r.p.m. and 10 h.p. at 12,000 r.p.m. The complete head is designed as a unit, and can be removed from the machine very quickly for overhaul or servicing.

The work-head is V-slide mounted and can be traversed through 12 in. of vertical movement by means of a hand-wheel, which operates the slide through bevel gears and a screw and nut. The hand-wheel has a graduated dial for accurate measurement of the slide movement. A lock is provided to hold the slides rigidly in any position. To enable the head to be lifted quickly out of its working position and returned accurately, as would be necessary, for example, when moving from one machined pocket to another, a separate movement of 4 in. is provided for by lifting the guiding handles. A spring-loaded plunger engaging in hardened bushes locates the slide at each end of the 4-in. travel. A multiple-stop depth control is also incorporated in this 4-in. movement so that the head can be brought down to different predetermined depths.

An optional extra feature is a dial indicator, graduated in 0·001 in. divisions, and fixed to the radial arm carrying the router head. This indicator is arranged to make contact with an adjustable stop on the slide, and enables the operator to bring the head back to any predetermined position within 0·001 in.

### RADIAL ARM HEAD SUPPORT

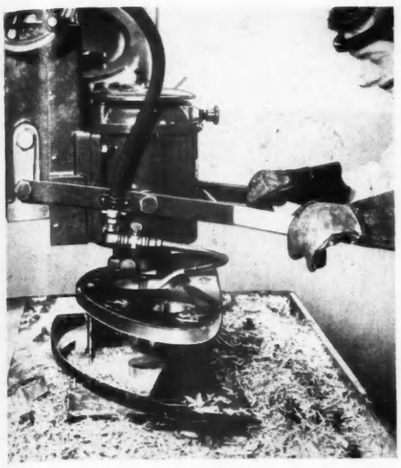
The head is mounted on a radial arm, with 360-deg. rotation, which is carried by a central column. In addition, the arm slides in a horizontal plane on top of the column, and the head can thus be traversed to any point in an annular path. The maximum and minimum radii of the head from the centre of the column are 5 ft. 5½ in. and 2 ft. 5½ in. respectively, and the annulus traversed by the head is thus 3 ft. wide, this figure representing the stroke of the radial arm.



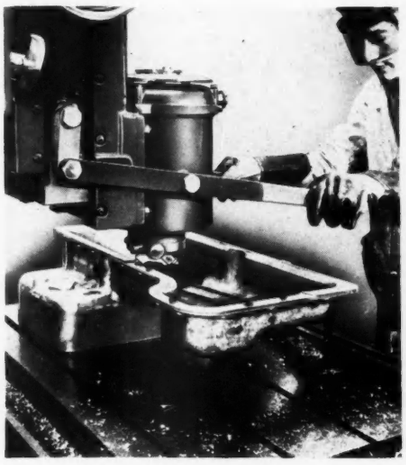
**Internal or external profiles can be finish-machined after band-sawing by using a side-cutter and a template.**

The radial arm is a heavy aluminium alloy casting, and it is supported by four Nitralloy rods which run in ball-bearing rollers mounted in a cast iron roller box on top of the column. The bearings are widely spaced to ensure maximum rigidity, and seven of them are eccentrically-mounted to enable the arm to be set accurately in the horizontal plane. The eighth bearing is rigidly fixed to provide a basic location. Three of the Nitralloy rods are flat and the fourth is round to control the straight-line action of the arm.

Heavy-duty ball bearings are used to carry the roller box on the central column, which is a one-piece ribbed casting incorporating a dust-proof and oil-proof compartment for the electrical switch gear. A radial stop is provided in the column to prevent the arm from moving through more than 360 deg., thus ensuring that the electric cables and the coolant pipe are not twisted. Machined faces are provided at the



Cutting thick plates or packs of thin sheets is similar to profile-finishing. Internal profiles can be pierced by using the fall of the head.



Face milling is done with an inserted-tooth cutter, the head being guided manually as in the other operations.

With suitable fixtures and templates several different machining operations can be done at one setting. A tungsten-carbide cutter is being used here for under-facing.

front and rear of the column. The front face is designed to accommodate a coolant tank and pump and a power-operated table, and the rear face takes a 6 ft. by 3 ft. 6 in. base plate. The front table and rear base plate are optional equipment and either or both can be omitted or modified as required.

### TYPES OF MACHINING POSSIBLE

The powered work table is normally supplied with a table top size of 3 ft. 6 in. by 2 ft., but other sizes are available. It is provided with T-slots for ½-in. bolts, and has vertical slides giving a maximum rise and fall of 11 in. The table is powered by a ½-h.p. electric motor with push-button control at an easily accessible point at the front of the machine. The stretcher between the table and the central column is used, when required, to house a coolant tank which is provided with a 0·2-h.p. motor and pump to circulate the coolant to the work. A compressed-air coolant circulating system is also available, which takes air from the shop supply line and supplies coolant to the cutter in the form of a mist.

The Wadkin router is capable of a large variety of machining operations, only a few of which can be mentioned here.

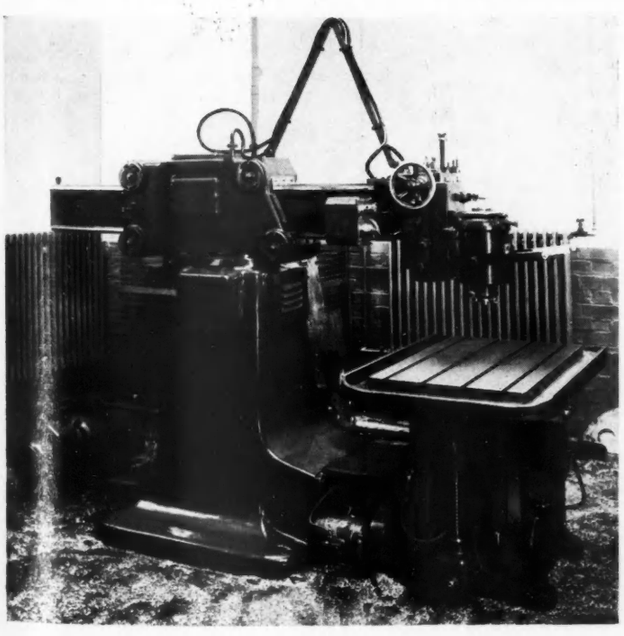
Routing components from the solid is an operation which is increasingly called for in the aircraft industry. For this purpose the router is equipped with a tungsten-carbide tipped tool, and both internal and external shapes of irregular form are produced by sinking the cutter into the material in a series of shallow steps. A template is used to guide the cutter which has a guide-bush mounted on it. A range of standard cutters is available for this type of work, and special cutters can be designed to suit particular profiles.

Deep internal or external profiles can be finish-machined after band-sawing roughly to shape. The maximum thickness of material which can be machined is 3 in. The operation is similar to the deep-milling procedure, but a side-cutter is used. A template is mounted on top of the component being machined, and the cutter carries a guide-bush as before.

Cutting thick plates or stacks of thin sheets is again similar to the previously-described operations, a template and a side-cutter being used. Thicknesses of up to 1 in. can be worked. With an end-mill type of cutter the plate or stack of sheets can be pierced to shape an internal profile.

Face milling is another operation for which the router is particularly suitable. For this purpose an inserted-tooth cutter is used, and the high speed of cutting and low tooth loading ensure an absence of chatter. Only very light clamping is necessary, and there is no distortion of the component. No template is needed for this type of work, the cutter head being guided manually over the work.

There are also many special applications for which the router is suitable. By using suitable fixtures and changing the cutters as required, a series of machining operations can be carried out at a single setting of the work. These include profiling inside and outside contours, under-facing, and cutting of sealing grooves.



The Wadkin heavy-duty router is manually operated and can be used for a large number of machining operations on non-ferrous alloys, as shown in the other illustrations. Different types of work-table can be fitted for special applications.

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## FABRICATED AND BONDED PLASTIC

### *New Industrial Uses*

The Edison Swan Electric Company, Limited, 155 Charing Cross-road, London, W.C.2, have developed methods for producing polytetrafluorethylene (P.T.F.E.) bonded to metal or rubber, P.T.F.E. bonded fibre-glass laminates, continuous lengths of P.T.F.E. cylinders, and beakers in P.T.F.E. for laboratory use. Hitherto polytetrafluorethylene—a resin-like substance unique among organic compounds for its chemical inertness, its toughness over a wide temperature range, its excellent insulating properties, and its low coefficient of friction—has presented difficulties in fabrication.

Metal-backed P.T.F.E. is likely to find many applications in the electrical industry. It can be readily fixed to any support by soldering or mechanical means. The adherence of the bond is such that satisfactory hermetically-sealed joints can be achieved.

Bonded with rubber, P.T.F.E. combines the flexibility of rubber with the chemical inertness of polytetrafluorethylene. Laminates of this type make excellent valve and pump diaphragms, washers, seals and flexible couplings.

P.T.F.E.-bonded fibre-glass laminates have good electrical and mechanical properties at extremes of temperature. They are already being employed as electrical insulators on high-performance aircraft and in other similarly arduous conditions.

Continuous cylinders of P.T.F.E., in a range of diameters and lengths, have applications in food-processing and similar machinery, for covering rollers handling sticky materials.

# HIGH-SPEED LABORATORY MILL

## *Generation of Turbulence*

A new high-speed laboratory mill has been developed by Steele and Cowlishaw, Limited, Cooper-street, Hanley, Stoke-on-Trent, which, it is claimed, will improve considerably existing small batch production and laboratory milling. The manufacturers state that after completing a series of over 400 laboratory tests on a wide range of materials, it has been proved that the new mill will grind and disperse materials in one-tenth of the time normally taken by an orthodox ball or pebble mill. It will also mill to semi-paste consistency, grind materials wet or dry, and if necessary, can process four different substances simultaneously. Formulations processed in this new mill can be reproduced in bulk production with identical characteristics; the time factor is the only variable.

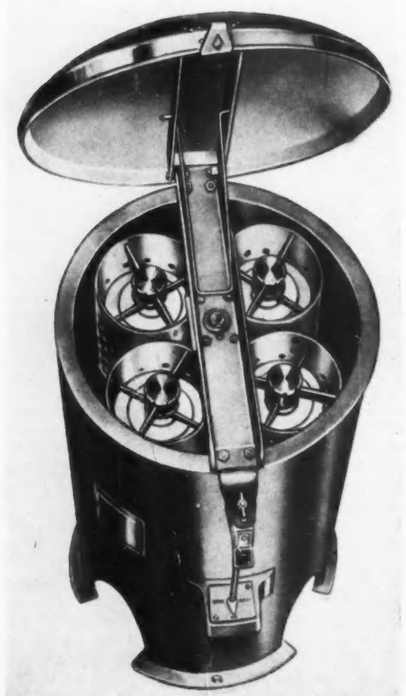
The mill consists essentially of a centre spindle around which revolve four vertical containers of five pints total capacity, in normal planetary motion. The centrifugal force developed by spinning the main spindle at speed is transmitted to the grinding media in the vertical containers. The latter, revolving on their own axes in a contrary direction, create considerable turbulence in the grinding media while the balls or pebbles are being pressed together and against the outer wall of the container by the main centrifugal force. The grinding capacity is 2½ pints of material per pot.

The whole of the working parts are enclosed in an oil-tight aluminium gearcase. All bearings are of the ball type, of a size considerably in excess of those necessitated by the working stress of the machine. The centre spindle is driven by a geared motor unit situated in the base of the casing, the latter being provided with a hinged lid which, when closed, totally encloses all parts of the machine, thus preventing accidents due to revolving pots.

While the mill has a wide range of uses and applications, it is particularly suited to the paint industry and the paint manufacturers' laboratory. For example, it will grind and disperse a concentrated charge of colour pigment and medium in approximately four hours, a process which normally takes at least 40 hours in an orthodox ball or pebble mill. Alternatively, it will produce a much superior dispersion in five, six or seven hours' milling time. Manufacturers' test reports quote specific dispersion times: carbon black, 3 hours; gloss green, 4½ hours; and prussian blue, 5 hours.

Furthermore, it is claimed that materials which previously have proved almost impossible to disperse satisfactorily in orthodox ball mills can be processed rapidly and efficiently in the new mill.

The pots are removable and interchangeable, and so placed that a complete change-over of materials can be carried out in two or three minutes. Standing time is reduced to a minimum since it is unnecessary to clean the mill between runs, the only delay in production being the substitution of freshly-charged spare pots.



**A high-speed laboratory mill in which the four "pots" rotate individually on their own axes and together, in the contrary direction, on the main axis.**

* * *

# NON-FERROUS METAL TUBES AND THEIR APPLICATIONS

## *Two Colour Films*

The methods, techniques and equipments now in use for the manufacture, fabrication and testing of non-ferrous metal tubes, and assemblies involving tubes, were shown in London recently in two interesting films in colour produced by the Yorkshire Copper Works, Ltd., Leeds, and Barrhead, Glasgow.

The first of the two films, entitled "The Plumbers' Way," is a 10-minute three-dimensional instructional film showing a craftsman plumber at work putting pipes and tubes in position in buildings, etc.

The second film, entitled "The 'Yorkshire' Point of View," shows how the tubes are produced and tested, and some of their land and marine applications. Many of the service, maintenance, development and research operations carried out are also depicted in the film which runs for about 30 minutes.

* * *

# ELECTROMAGNETIC BRAKES AND CLUTCHES

## *Smooth Controllable Operation*

Now being manufactured in this country by Westool Limited, St. Helens Auckland, Co. Durham, are the Warner electromagnetic brakes and clutches that have been made for some time in the United States of America. The claims for both brakes and clutches are that they offer lightweight compact units with a high torque which can be smoothly and quickly applied.

The standard form of brake is shown in Fig. 1. Basically it consists of an electromagnet contained in a steel housing forming the stationary member and a revolving armature plate attached to the shaft. Alternatively the armature can be attached direct to a pulley or flywheel. The application of a direct current to the magnet attracts the armature, which is held by self-compensating driving pins, and the friction material lining the two faces exerts the braking effect. To dissipate the heat generated and to give rigidity, the armature backing plate is fluted. The mating face is segmented to allow for expansion.

### CURRENT THROUGH SLIP RINGS

The clutch unit is generally of a similar construction but, since both portions are rotating, the current is fed to the magnet through slip rings. Clutch and brake can be combined, as shown in Fig. 2, to form a compact unit which may, in some cases, be mounted entirely within the driving pulley.

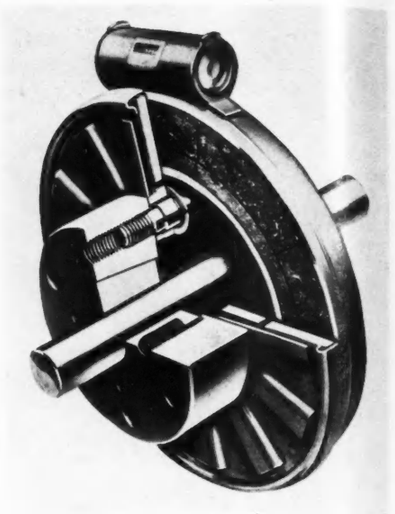


**Fig. 1 In the brake unit, the magnet is the stationary member. Wear on the friction lining is automatically taken up.**

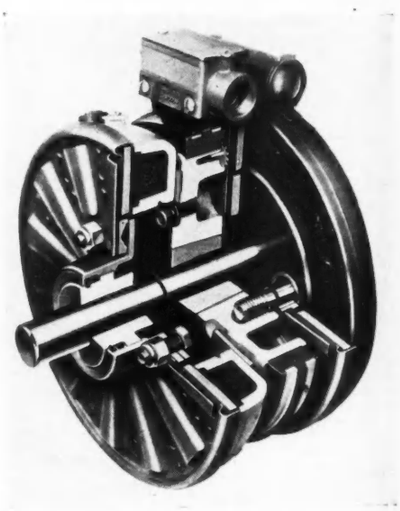


**Fig. 2 Brake and clutch can be combined to form a compact unit while retaining separate control of each.**

Power consumption by the magnet is comparatively small, being between 10 and 35 watts; it can be supplied from a rectifier on the control panel. Models are made to operate at 6 or 90 volts and to give the torque required. Although response times can be made very short—less than 0·01 second is possible—the progressive build-up of the current relieves shock loading of the parts. Control can be by a series rheostat which will give smooth variation of the torque applied. It also allows automatic operation to be introduced quite simply.

Any wear occurring on the friction lining material is taken up automatically, allowing consistent performance to be maintained. The range of applications is wide and includes most machine tools. The operation is claimed to be smoother than is obtainable with any purely mechanical device.

**This quick-response electronic voltage stabiliser has a maximum variation of 5 millivolts for a change in mains voltage of 10 per cent.**

## VOLTAGE STABILISER

### *Output up to 2·5 amperes Direct Current*

A quick-response voltage stabiliser has been introduced by Servomex Controls, Limited, Crowborough Hill, Jarvis Brook, Sussex. The complete instrument is shown in the illustration above. Currents up to 2·5 amperes can be taken continuously from the direct current output. Even when switched direct on to full load, the correction time is only about 5 milliseconds.

The instrument is capable of correcting mains variations of ± 10 per cent. with an output variation of less than ± 5 millivolts. The reference voltage is given by a Mullard 85A2 valve for which a stability of within 0·1 per cent. over 100 hours is claimed. For the whole instrument under normal working conditions, the voltage drift does not exceed 2 millivolts a day. Tappings are provided for 200, 210, 220, 230, 240, or 250 volts nominal, 50 or 60 cycles. Models can also be supplied for 100 or 120 volts.

* * *

## COAL CONVEYORS

### *Film Demonstrates Practical Difficulties*

Engineering work in mines is beset by unusual difficulties. There is a limit to the size and weight of items that can be moved; the space to work in is limited; the time to work in is limited if output of the pit is not to be affected. All these difficulties and the ways in which they are overcome are most realistically portrayed in the film "Trunk Conveyor," made by the film unit of Richard Sutcliffe, Limited, Horbury, Wakefield. The film, which runs for approximately 30 minutes, is available in 35-mm. and 16-mm. sizes.

Some of the points made in the film are: the manufacturer's advice should be obtained so that the most suitable equipment is chosen; discussion with the colliery staff will help to ensure that the advantages of the new equipment are appreciated and that initial snags will be few; the installation must be planned to the last detail so that equipment is delivered in good condition to the pit bottom in the order required, and so that there is as little interference with production as possible. The film shows the delivery of the equipment to the site, and the erection of the complete conveyor.

This film could be shown with advantage to the staff of a colliery where a trunk conveyor is about to be installed. The staff could then see in general terms what has to be done, and pick up several practical hints for running their own installation.

* * *

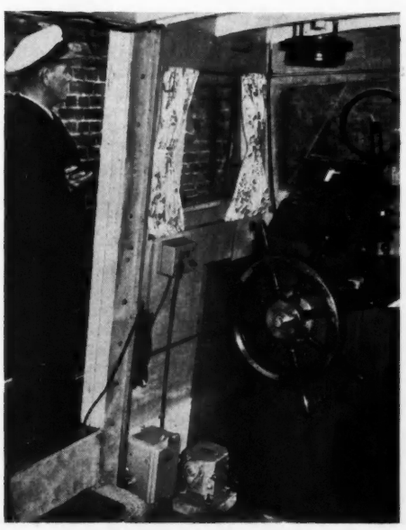
## AUTOMATIC STEERING DEVICE

### *Compact Electronic unit for Small Craft*

The "Martinet" electronic helmsman is an automatic steering device designed particularly for small craft, such as yachts and trawlers, but which can also be used by larger vessels fitted with powered steering. The apparatus has been produced jointly by the Marconi International Marine Communication Company, Limited, Chelmsford, and Hartley Electromotives, Limited, 1a Harrington-road, London, S.W.7, and will be shown at the forthcoming National Boat Show. The illustration shows the equipment mounted in the research vessel Elettra II, with the captain using the remote-control unit.

Full technical details have not yet been released, but the primary control is by terrestrial magnetism. When a course has been set, the apparatus is switched on, and thereafter any deviation of the "compass" of the apparatus is transmitted electronically to a relay circuit controlling a small electric motor. This is connected to the steering wheel by a chain drive, as may be seen in the illustration, and makes the necessary correction to bring the ship's head back on course again. The degree of control is adjustable to suit the conditions encountered, as in a heavy seaway or when in narrow waters.

An additional feature is the remote control that is shown in use in the illustration. This gives full steering control with fine adjustment from any position on board, enabling the helmsman to be in the best position for observation. No expensive gyro-compass is required to operate the equipment, and power can be supplied by a 12- or 24-volt battery or alternatively from 110-volt direct-current mains.



**The relay unit and the steering motor of the automatic helmsman are mounted on the deck below the steering wheel with the control unit above them on the bulkhead. The officer is holding the remote-control unit.**

## LAUNCHES AND TRIAL TRIPS

M.S. "RANWORTH QUEEN."—Single-screw trawler, built by John Lewis and Sons, Ltd., Aberdeen, for Talisman Trawlers, Ltd., Lowestoft. Last of a series of four vessels for these owners. Main dimensions: 100 ft. between perpendiculars by 20 ft. by 10 ft. 9 in. Six-cylinder Diesel engine, developing 440 b.h.p. at 300 r.p.m., constructed by Crossley Brothers, Ltd., Openshaw, Manchester. Launch, November 11.

H.M.S. "DUFTON."—Twin-screw coastal minesweeper, built by the Goole Shipbuilding and Repairing Co. Ltd., Goole, for the Admiralty, London, S.W.1. Main dimensions: 152 ft. by 28 ft. 9 in. by 14 ft. 9 in.; armament, three small guns. Diesel propelling machinery supplied by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, November 13.

M.S. "CERRO BOLIVAR."—Single-screw ore-carrying vessel, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for the Joshua Hendy Corporation, Los Angeles, California, U.S.A. Main dimensions: 549 ft. 4½ in. by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, about 18,600 tons on a draught of 29 ft. 10 in. Eriksbergs-B. and W. six-cylinder single-acting two-stroke Diesel engine, developing 7,500 i.h.p. Speed, fully loaded, 15¼ knots. Launch, November 15.

S.S. "JOSEPH KNIBB."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for H. Croft Baker and Sons, Ltd., Grimsby, a subsidiary of Trawlers Grimsby Ltd., Grimsby. Main dimensions: 137 ft. 6 in. between perpendiculars by 28 ft. by 14 ft. 3 in.; gross tonnage, about 440. Triple-expansion steam engine, developing about 750 i.h.p., and one oil-burning boiler, constructed by Amos and Smith Ltd., Hull. Launch, November 16.

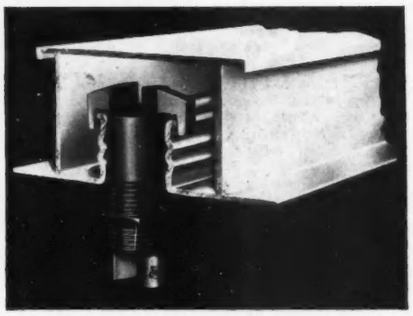
M.S. "POLYCLIPPER."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Einar Rasmussen, Kristiansand, Norway. Main dimensions: 526 ft. by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, 18,125 tons on a draught of 30 ft. 4¾ in.; oil-tank capacity, about 860,000 cub. ft. Eriksbergs-B. and W. nine-cylinder single-acting two-stroke Diesel engine, developing 9,000 i.h.p. Speed, 15¼ knots, fully loaded. Delivered, November 18.

M.S. "DONA EVGENIA."—Single-screw oil tanker, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Compañia Panamena Europea Navegacion Limitada, Panama (Agents: Chandris (England) Ltd., London, E.C.3). Main dimensions: 505 ft. by 69 ft. 9 in. by 39 ft.; deadweight capacity, 16,730 tons on a draught of about 30 ft. 1 in. Doxford five-cylinder opposed-piston oil engine. Trial trip, November 22.

M.S. "PRESIDENT BRAND."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the Northern Steamships Ltd., Johannesburg. Main dimensions: 560 ft. between perpendiculars by 80 ft. by 42 ft. 3 in. to upper deck; deadweight capacity, 24,600 tons on a summer draught of 32 ft. 3½ in. N.E.M.-Doxford six-cylinder single-acting two-stroke opposed-piston oil engine, developing 6,800 b.h.p. at 119 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 14 knots. Trial trip, November 23.

S.S. "HADRIANIA."—Single-screw oil tanker, built by Smith's Dock Co., Ltd., South Bank-on-Tees, for Shell Tankers, Ltd., London, E.C.3. Second of a series of five vessels for these owners. Series constitutes the largest ships built by this firm. Main dimensions: 557 ft. overall by 69 ft. 3 in. by 39 ft.; deadweight capacity, about 18,100 tons on a draught of 29 ft. 9½ in. Double-reduction geared steam turbines and two Foster Wheeler oil-burning boilers, constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne, and installed by the shipbuilders. Service speed, about 14½ knots. Trial trip, November 23.

S.S. "BENDIGO."—Single-screw cargo vessel, built and engined by Alexander Stephen and Sons, Ltd., Glasgow, for the Peninsular and Oriental Steam Navigation Co., London, E.C.3. Sister ship to the S.S. Ballarat. Both vessels designed for the company's Australian wool trade. Main dimensions: 490 ft. between perpendiculars by 69 ft. by 43 ft. to shelter deck; deadweight capacity, 12,870 tons on a draught of 29 ft. 8¾ in.; gross tonnage, about 8,782. Geared steam turbines developing 11,000 s.h.p. in service. Steam supplied by two Foster Wheeler oil-burning boilers, of sufficient capacity to allow the vessel to proceed at 16½ knots with only one boiler in use. Service speed, 18 knots. Delivered, November 25.



**The conduit, made from an aluminium extrusion, can be suspended or mounted flush in the ceiling. Fittings can be attached by T-bolts.**

## ALUMINIUM WIRING CONDUIT

### *Provision for Suspended Fittings*

" Invertrunking " is a form of conduit made from aluminium extrusion that has been introduced by the British Thomson-Houston Company, Limited, Crown House, Aldwych, London, W.C.2. A section is shown in the illustration above. One of the advantages claimed is that fittings can be suspended from the trunking by means of the T-bolt shown in the illustration. The trunking itself can be mounted flush in the ceiling or suspended from it by rods to suit the design of the building.

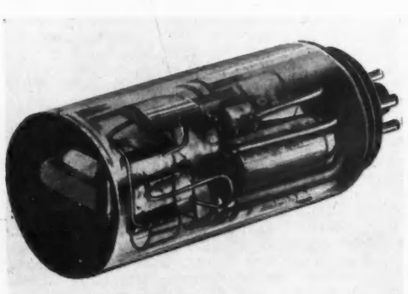
The cables are laid in the channels on each side of the centre portion and are covered with a spring-steel fillet when all are in position; this can quickly be removed when it is desired to make any alterations. Section lengths are joined by a short channel section held in place by self-tapping screws or Pop rivets. Angles, T and crossover sections are available and also special connector blocks which allow the wiring to be reached after the ceiling has been completed. The broad flanges of the trunking are designed to support standard types of ceiling tile when a suspended ceiling is being used. The trunking is 4 in. wide and $1\frac{1}{16}$ in. deep.

★ ★ ★

## PROTECTING ELECTRONIC CIRCUITS

### *Components Set in Resin Capsules*

To protect sub-circuits and components of electronic equipment from mechanical shock and vibration, and to add to their general robustness, Lion Switchgear Limited, Twickenham-road, Hanworth, Middlesex, have developed the " Leocast " process, whereby complete electrical units consisting of several items can be enclosed in resin capsules. The capsules are free from air and voids, and by the use of different resins they can be adapted to a wide range of conditions. A typical composite component is shown in the accompanying illustration.



**Example of electronic circuit in resin capsule to protect it from damage.**

The nature of the components to be included in a circuit, and its application, influence the choice of resin, and various filling materials can be employed to improve such qualities as heat conductivity, capacity to accommodate internal expansion and dielectric strength; the makers claim that dielectric strengths as high as 500 volts per 0·001 in. can be achieved. Critical inter-component capacities and dielectric constant, and the humidity and temperature under which the unit is expected to operate are other factors to be considered in selecting a resin. The temperature variation permitted with standard units extends from − 40 deg. C. to + 70 deg. C., but in special cases variations from − 70 deg. C. to + 100 deg. C. can be tolerated.

The weight of the components is only slightly increased by the capsule, since one cubic inch of resin weighs only approximately $\frac{3}{8}$ ounce. Opaque resins can be employed to shroud circuits for security purposes and coloured resins can be used if a colour code is required.

The replacement of a complete sub-circuit is necessarily more expensive than changing a single component, but the length of life of units amply compensates for this. There is also the further advantage that repairs can be effected very quickly by the replacement of entire circuits. Examples of Leocast units were exhibited at the seventh London Regional Display of the Engineering Industries Association.

★ ★ ★

## STORY OF PETROLEUM

### Royal Institution's Christmas Lectures

The one hundred and twenty-fifth course of six lectures of the Royal Institution, specially " adapted to a juvenile auditory," will deal with " The Story of Petroleum," and will be delivered by Air Commodore Sir Frank Whittle, K.B.E., C.B., F.R.S., at the Institution, 21 Albemarle-street, London, W.1, on Tuesdays, Thursdays and Saturdays, December 28 and 30, 1954, and January 1, 4, 6 and 8, 1955, commencing in each case at 3 p.m.

Subjects to be dealt with will include the geology, exploration, production, transportation, refining, and uses of petroleum; engines and their fuel; and the gas turbine. Fees for the course will be £1 for juveniles aged 10 to 17, and £2 for all other persons, except members of the Institution. Applications for tickets should be sent to the Institution at the above address.

★ ★ ★

## PULVERISED FUEL ASH AS A BUILDING MATERIAL

An exhibition of building materials and other products containing pulverised fuel ash has been arranged by the British Electricity Authority at Winsley-street, London, W.1; it gives a good indication of how a material which would otherwise be wasted, and the disposal of millions of tons of which is frequently a problem, can be usefully employed.

As typical of these products and their application mention may be made of the concrete which is being used to form the top section of the coal wharf slabs at Thornhill power station. The mix consists of 7 cub. ft. of gravel, $3\frac{1}{2}$ cub. ft. of sand, $1\frac{1}{2}$ cub. ft. of cement and $\frac{1}{2}$ cub. ft. of pulverised fuel dust, thus replacing about 20 per cent. of the cement that would otherwise have been necessary. Tests on cubes with cross-sectional areas of 36 sq. in. and weights of 18·21 and 19·13 lb. gave compressive strengths of 1,900 and 2,240 lb. per square inch. A typical building block, which is on view, is composed of 1 part of cement, 5 parts of Leca and 5 parts of pulverised fuel ash, while the composition of another, which has passed the test requirements of B.S. 2028, is 1 part of Portland cement, $1\frac{1}{2}$ parts of pulverised fuel ash and 7 parts of foamed slag.

Samples of bricks include those made with 80 or 75 per cent. pulverised fuel ash and 20 or 25 per cent. Blaes. There are also a number of Thermatite light-weight load-bearing insulating blocks and Melcrete tiles in the manufacture of which ash has been employed. Blocks of this type are being used to build 2,000 houses in the neighbourhood of the Braehead power station near Glasgow. A reinforced concrete gate post contains 1 cwt. of Portland cement, 28 lb. of pulverised fuel ash, $1\frac{1}{2}$ cub. ft. of sand and 3 cub. ft. of $\frac{3}{8}$-in. shingle. Plain concrete made of a mix of 1 part of cement to 6 parts of ash by volume has a density of 82 lb. per cub. ft., a compaction factor of 0·77 and a compressive strength after seven days of 900 lb. per square inch.

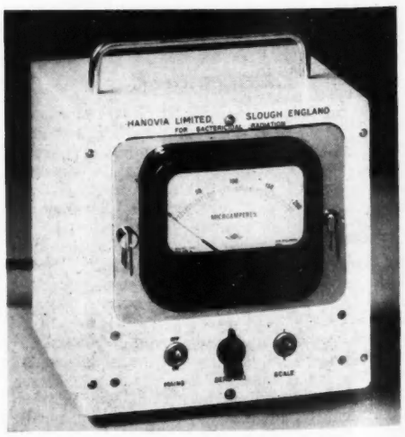
★ ★ ★

## MEASURING ULTRA-VIOLET RADIATIONS

### *Instrument for Detecting Undesirable Short Waves*

A meter has been developed by Hanovia, Limited, Bath-road, Slough, Buckinghamshire, for measuring short-wave ultra-violet radiation such as is associated with low-pressure mercury discharge lamps used in bactericidal equipment. In this instrument, the meter can be removed from the main assembly while measurements are in progress, so that the operator need not be exposed unduly to the radiations.

The instrument contains a three-valve bridge circuit, the balance of which is controlled by two photo-electric cells in quartz envelopes. The degree of balance is indicated by the micro-ammeter which can be seen in the illustration. The two photo-cells are mounted behind a rectangular opening in the casing of the instrument, the opening being fitted with a shutter of special glass. One cell is enclosed in a glass cylinder, and any ultra-violet radiation falling on the cells is therefore recorded unequally and the resulting unbalance is shown on the meter. The instrument is sensitive to low intensities, and is fitted with an attenuator grating for use near to high-output sources.




**Meter for measuring short-wave ultra-violet radiation. It is designed for use in conjunction with bactericidal equipment.**

Fig. 1 The new coal preparation plant at Mansfield Colliery utilises both the heavy-medium and froth flotation processes to handle over 400 tons of coal per hour.

# COAL PREPARATION BY FLOTATION

## ENTIRE MINE OUTPUT TREATED

As part of the recent reorganisation of Mansfield Colliery, a new coal preparation plant has been installed. It is believed to be the first in the world which will clean the whole output of a pit by a combination of the heavy-medium and froth flotation processes. The mechanical section of the plant was supplied by the Fraser and Chalmers Engineering Works of the General Electric Company, Limited, at Erith, Kent, who also acted as main contractors. Unifloc, Limited, 2 St. Mary's-street, Swansea, were responsible for the froth flotation plant together with the rotary vacuum filters and the water clarification plant, while the conveyors and screens were supplied by Plowright Brothers Limited, Chesterfield.

The reorganisation became necessary as the Top Hard seam was rapidly being worked out, and it was decided to work the High Hazel Seam. Underground, tram winding was abolished and replaced by mine cars and Diesel locomotives with a skip hoist in the No. 2 (coal) winding shaft. Provision has been made for using No. 1 shaft for coal in an emergency, but normally it will be used for men, stone and materials only. Electric winding has also been installed. The external appearance of the completed handling plant and buildings is shown in Fig. 1. The output that it will handle is more than 400 tons per hour.

### CHOICE OF PROCESS

The Chance sand flotation process for coal washing was introduced into this country some years ago by the Fraser and Chalmers Engineering Works. The process has the ability of cleaning all sizes of coal down to $\frac{1}{16}$ in. square and has been used extensively where the coal was extracted dry. The introduction of underground water infusion and spraying, however, made it impossible to extract the fines by dry screening as had previously been done. Experiments in the laboratory and in pilot plant showed that wet screening was quite effective in separating sizes below $\frac{1}{16}$ in. using modified dry screening plant. Further, the water/solid ratios required proved to be within the range normally used for flotation, and also were adequate for wet scalping the raw coal feed at a nominal size of $\frac{1}{2}$ in. and for laundering this fraction from the scalping to the vibrating screens.

Experiments in froth flotation showed that it was quite possible to deal with sizes up to $\frac{1}{16}$ in. and no difficulties were encountered in the filtration of concentrates with particles up to this size, or in clarification. The sum of these experiments showed that a complete plant utilising the heavy-medium and froth flotation processes was quite feasible, and it was arranged for one to be installed at Mansfield. The original plant there consisted of hand cleaning for sizes down to 4 in., a jig washery for 4 in. to 1 in., and a trough washer for the rest. Not least among the difficulties of building the new plant was that the old had to be kept in commission until the new could take over the work. The actual replacement was carried out section by section at weekends.

### SEPARATION BY A HEAVY MEDIUM

From a study of the raw coal, it became apparent that the various products required could best be obtained by installing two Chance cones for dealing with the coals above $\frac{1}{16}$ in. in size. The reason for this decision was that the sizes above $\frac{1}{2}$ in. round contained a certain proportion of intergrown middlings which could be improved upon crushing, whereas it was not considered worth while to produce middlings in the $\frac{1}{2}$ in. round to $\frac{1}{16}$ in. square fraction, in which a higher ash content was permissible than with the over $\frac{1}{2}$ in. fraction. Consequently, one 14-ft. diameter Chance cone was installed with middlings-extraction equipment, for dealing with the over $\frac{1}{2}$ in. size; and a second cone, of the same diameter, but without the middlings-extraction equipment, was included for dealing with the $\frac{1}{2}$ in. round to $\frac{1}{16}$ in. fraction. The mechanical parts for both cones are identical and interchangeable which, of course, simplifies maintenance. The No. 1 cone is illustrated in Fig. 2.

Separation by a heavy-medium process utilises the relative densities of the materials; in this application the medium used is sand. The raw coal and the sand are fed into the Chance cone, a cut-away section of which is shown in Fig. 6, and are mixed and agitated by jets of water and mechanical paddles. The mixture then acts as a solution and the lighter elements rise through it while the heavier portions sink. The quantity of water injected has to be controlled to maintain the right degree of fluidity. In this case, the clean coal, being lighter than the sand, rises to the top of the cone and is carried away down the overflow by the excess water. The heavier dirt and stone sinks to the bottom and is removed through the refuse gates together with the excess sand. The pneumatic cylinder which operates the upper gate can be seen in the foreground of Fig. 2 and in the section, Fig. 6, page 771.

The No. 1 cone at Mansfield colliery is fitted with a middlings column, as shown in Fig. 6, through which intergrown stone and coal can be extracted. This is later crushed for further separation, as the crushing will break up the mixed lumps and enable the stone to be removed. Water is used to flush the middlings up the column to the launder.

### FLOW OF MATERIAL

The raw coal is normally brought up the No. 2 shaft in 7-ton capacity skips and discharged on to a plate feeder belt, *a* in Fig. 4, through a 10-ton receiving bunker, which also acts as an air seal. Three doors are fitted to the bunker, two at the top and one at the bottom, and they are controlled by compressed air, the valves being operated by the skips as they reach and leave their discharge position. The bottom door closes when the top door opens and vice versa, and a photo-electric device is fitted to warn the engineman if the door of the skip fails to close securely. The air seal is required on the shaft in order to maintain air circulation in the mine.

It was found convenient to screen out the 8-in. round to 0 fraction from the run-of-mine feed to the plant, and to crush the over 8 in. to below 8 in. The over 8 in. fraction contains a large percentage of intergrown material which is released on breaking. Thus the run-of-mine

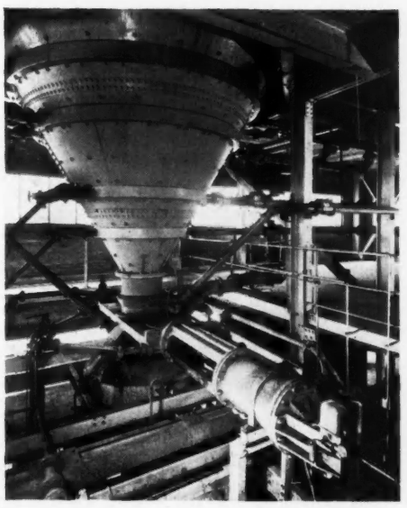


Fig. 2 The No. 1 cone of the Chance sand-flotation process handles coal above $\frac{1}{2}$ in. in size. Middlings of intergrown coal and stone are extracted for crushing and further treatment.

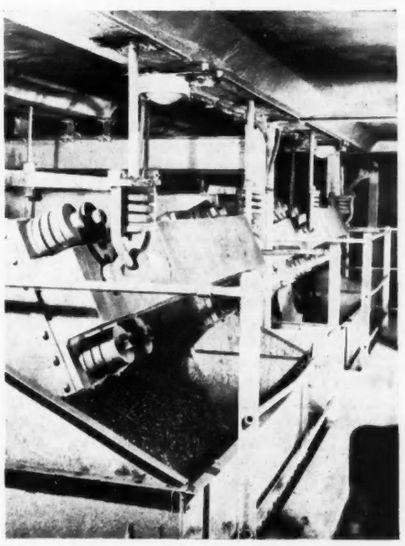


Fig. 3 Wet screening of the $\frac{1}{2}$-in. to 0 fraction to give a separation at $\frac{1}{16}$ in. proved practicable with vibrating screens.

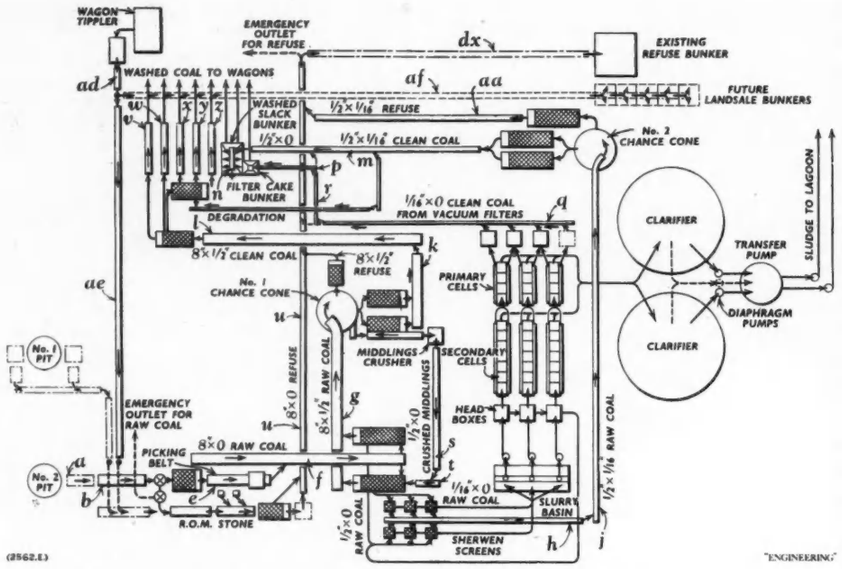



**Fig. 4 Diagram of the flow of coal through the plant.**

coal is delivered to the primary screen from the plate feeder belt *a* by belt conveyor *b* in order to make the separation at 8 in. From this screen the 8 in. to 0 fraction passes directly to conveyor *f*, while the over 8 in. size is fed on to picking belt *e*. The latter is used for the removal of any exceptionally large pieces of stone, together with tramp iron, pit props, etc., and it is fitted at its discharge end with a Plowright pick breaker to reduce the over 8 in. coal to below 8 in. This broken coal then joins the "natural" 8 in. to 0 coal on conveyor *f* for delivery to the main section of the coal-preparation plant.

Facilities are also included on the picking belt whereby a special hand-picked selected large coal can be delivered directly to wagons, when required.

Conveyor *f* delivers the 8 in. to 0 raw coal on to the two secondary raw-coal screens for wet screening at ½ in. round, the 8 in. to ½ in. fraction being delivered to the No. 1 Chance cone by conveyor *g*. The ½ in. to 0 fraction, together with all the spray water, is laundered to a battery of six Sherwen electromagnetically-vibrated screens where a separation, by means of wet screening, takes place at 1/16 in. square. It is interesting to note that the separation takes place in the first 12 in. to 15 in. of the screens. These screens are shown in Fig. 3.

The 1/16 in. to 0 fraction, separated on the Sherwen screens, is laundered to a slurry basin, and from thence it is pumped to the flotation plant, while the ½ in. to 1/16 in. fraction is delivered to the No. 2 Chance cone by conveyors *h* and *j*.

The No. 1 Chance cone, as previously mentioned, is arranged for a three-product separation, namely: clean coal, middlings and refuse. The refuse, after de-sanding and de-watering, is delivered on to conveyor *u* and thence to an existing 200-ton aerial ropeway bunker by conveyor *dx*.

Meanwhile, the clean coal, from the No. 1 Chance cone is laundered on to a pair of clean-coal de-sanding and de-watering screens, and thence it is delivered by conveyors *k* and *l* to the sizing screens. The latter separate the 8 in. to ½ in. round clean coal into 8 in. to 4 in., 4 in. to 2 in., 2 in. to 1 in. and 1 in. to ½ in., for loading to wagons, by the boom loaders *v*, *w*, *x* and *z*, respectively. A spare boom loader, *y*, has been provided so that the number and range of the sizes may be altered to accommodate changes in the market requirements.

The 8 in. to ½ in. middlings fraction extracted from the No. 1 Chance cone by means of the middlings column, is de-sanded and de-watered on a section partitioned off on one of the clean-coal screens. This material is then crushed to below ½ in. in a Fraser and Chalmers Pennsylvania hammer mill, and returned to the secondary raw-coal screens by the conveyors *s* and *t* for separation into ½ in. to 1/16 in. and 1/16 in. to 0 fractions, for delivery to the No. 2 Chance cone and to the flotation plant respectively.

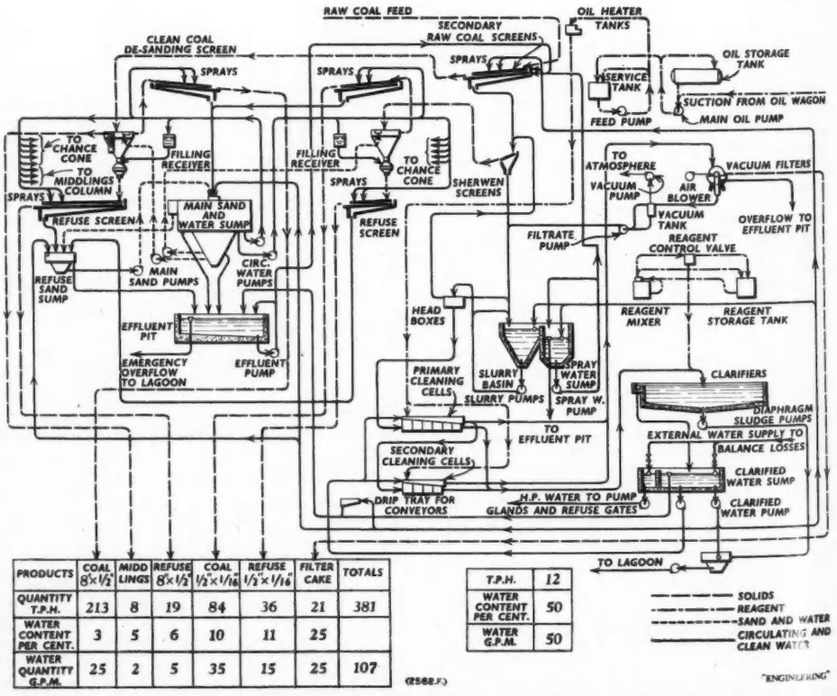
The No. 2 Chance cone is arranged for two-product separation only and the refuse, after de-sanding and de-watering, is delivered to the aerial ropeway bunker by the conveyors *aa*, *u* and *dx*. The clean coal is de-sanded and de-watered on another pair of shaker screens, and delivered to a 300-ton capacity loading bunker, by the conveyors *m* and *n*.

Meanwhile, the 1/16 in. to 0 raw coal, which passes into the slurry basin as already explained, is pumped to the flotation plant through the head boxes, the function of which is to remove any oversize material in the feed and also to control the quantity of slurry delivered to the flotation cells. The slurry from the head boxes passes to the three banks of primary cells, each bank consisting of seven cells. The concentrates from these cells may pass either directly to the three 200-sq. ft. Unifloc rotary vacuum filters or, alternatively, they may be re-treated in a set of three banks of secondary cells, each bank consisting, in this case, of four cells. At the time of writing it has been found possible to clean the 1/16 in. to 0 satisfactorily in the primary cells, without using the secondary cells. The tailings product from the primary cells and from the secondary cells is laundered to two 75-ft. diameter clarifiers.

After de-watering on the rotary vacuum filters, the filter cake is discharged on to conveyor *q* and thence to conveyor *r*. The latter is arranged with an adjustable chute so that the filter cake may be mixed with the washed slack on conveyor *m* or, alternatively, loaded to wagons separately by way of conveyor *p* and a filter-cake bunker. Provision has been made to permit installation of a further vacuum filter in the future, if the amount of fines increases.

As mentioned earlier, the tailings from the cells pass into two 75-ft. Unifloc clarifiers from which the clarified water overflows into a sump for re-use in the washery, while the thickened sludge is extracted from the bottom by means of two diaphragm pumps. These discharge into a transfer sump, from which two Fraser and Chalmers centrifugal sand pumps deliver the material a distance of over 800 yards to a lagoon. It is a notable feature that, due to the coarse size of the tailings, the solid material settles out remarkably quickly in the lagoon—to such an extent, in fact, that it is possible to pump the water back to the washery and thereby maintain a closed water circuit.

Experiments are now being carried out with both rotary vacuum filters and filter presses so




| PRODUCTS | COAL 8"×½" | MIDDLINGS | REFUSE 8"×½" | COAL ½"×1/16" | REFUSE ½"×1/16" | FILTER CAKE | TOTALS |
|---|---|---|---|---|---|---|---|
| QUANTITY T.P.H. | 213 | 8 | 19 | 84 | 36 | 21 | 381 |
| WATER CONTENT PER CENT. | 3 | 5 | 6 | 10 | 11 | 25 | |
| WATER QUANTITY G.P.M. | 25 | 2 | 5 | 35 | 15 | 25 | 107 |

| | |
|---|---|
| T.P.H. | 12 |
| WATER CONTENT PER CENT. | 50 |
| WATER G.P.M. | 50 |

**Fig. 5 The flow of water in the plant is an almost closed cycle, only a relatively small make-up being needed; also shown are the paths of the sand and other materials.**

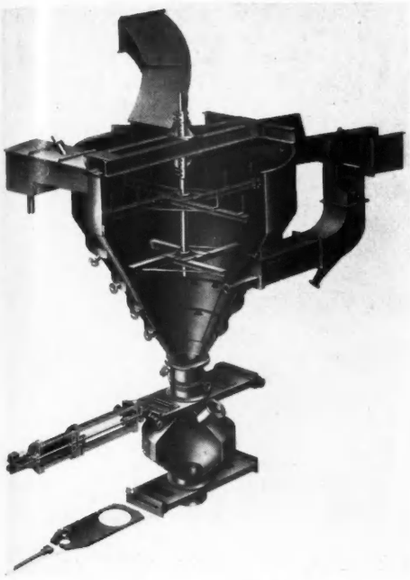


**Fig. 6 Separation by the heavy-medium process depends on relative densities. Raw coal is fed through the chute at the top, while the sand enters tangentially from the left. Water is injected through manifolds at different levels.**

that the tailings may be de-watered and sent to the tip along with the washery refuse.

### WATER CIRCUIT

The two-process combination of washing results in a very simple water circuit, and details of that for Mansfield are given in Fig. 5. Water is added on the secondary raw-coal screens for extracting the less than ½ in. coal, and this fraction, together with all the spray water, is laundered to the Sherwen screens for a further separation at $\frac{1}{16}$ in.

A small quantity of water is continuously bled from the Chance circuit to keep the solid concentration at a satisfactory value, and this effluent is used to assist the wet screening. The balance of the spray water is provided by the clarified-water pump. After it has been separated on the Sherwen screens, the $\frac{1}{16}$ in. to 0 fraction passes to the slurry basin, the function of which is to even-out the washing characteristics, and to steady the feed to the flotation cells.

The arrangement of the water circuit ensures that the fine material is extracted from the feed immediately it enters the plant, thereby avoiding a considerable measure of degradation, as recirculation is avoided.

All conveyors handling wet or sticky materials are provided with collecting troughs for spillage under the return side of the belt. These troughs are continuously flushed with water which is drained either to the slurry basin or effluent pit. The solids are, of course, recovered in the flotation plant.

The plant operates with a completely closed water circuit, the only make-up water required being that to replace the moisture lost with the various products.

### PIT STONE

In addition to the equipment for cleaning the raw coal, the plant includes facilities for dealing with run-of-mine pit stone. The stone may be brought up either of the two shafts and, after passing over a steel-plate picking belt, for the removal of any free coal, it is screened at 8 in., the over 8 in. fraction being reduced to below 8 in. in a jaw crusher. The whole of the 8 in. to 0 pit stone is then discharged on to the rubbish conveyor *u* and thence to the 200-ton aerial ropeway bunker. Winding of the stone usually takes place off-shift, but it is possible to handle it during the period of coal winding.

The rubbish-disposal facilities include arrangements at the discharge end of conveyor *u* whereby rubbish may be loaded into rail wagons in the event of the ropeway being out of commission. Other emergency measures include facilities for bringing coal or dirt up either of the shafts for delivery to the preparation plant, while if the plant is out of commission, raw coal or pit stone may be loaded to rail wagons and, at a later time, re-introduced into the preparation plant by means of a Marshall-type wagon tippler and the conveyors *ad* and *ae*.

### ELECTRICAL EQUIPMENT

The whole of the electrical equipment was designed and manufactured in the Witton Engineering Works of the General Electric Company and includes the driving motors, contactor-type control gear and also the low-tension distribution board. The G.E.C. was also responsible for the lighting and power wiring, the installation of which was carried out by the Electrical Equipment Company, Limited, Leicester.

All the driving motors, which operate on a 500/550-volt supply, are of the totally-enclosed fan-cooled dust and weatherproof type and both slip-ring and squirrel-cage machines have been installed. The whole of the contactor starting equipment is installed in a central switchroom for convenience in maintenance, while the various push-buttons for controlling the equipment are grouped about the plant on desks and wall mounting panels. Indicator lights are fitted on both the desks and panels to show whether or not a particular unit is running, while in certain instances ammeters, temperature recorders and other instruments are also provided.

The majority of the plant is electrically interlocked, in order to ensure that it is started up in the correct sequence and to avoid equipment becoming buried with material in a breakdown. Interlocking has been arranged, however, so that a minimum of equipment is tripped out by the sequence arrangements.

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## LORRY-MOUNTED EXCAVATOR

### *Versatile Machine of High Mobility*

The excavator mounted on a standard lorry chassis, shown in the accompanying illustration, is the " Poclain " hydraulic excavator which was on the stand of Winget, Limited, Rochester, Kent, at the recent Public Works Exhibition in London. The machine has nearly all the advantages of a track-mounted excavator—the 300-deg. slew should be sufficient for all practical purposes—but the high mobility for moving about on a large site or between sites gives it a distinct advantage over conventional equipment.

### DITCH CLEANING

The versatility of the Poclain is enhanced by the variety of front-end equipment that is available for it. These include a ¾-cub. yd. face shovel, a skimmer of the same capacity (a larger bucket of twice the capacity is also available for handling coke, breeze and similar lightweight materials) and trench hoes 18 in. and 25 in. in width. For ditch cleaning in fenland and other districts where maintenance of drainage ditches is of great importance a specially wide bucket 67 in. in width, is available. A curved blade, 19 in. deep by 4 ft. 7 in. wide, fitted to the skimmer equipment in place of the bucket can be used either outwards as a bulldozer blade or inwards for the back filling of trenches.

Power for the excavator is obtained from a Lister two-cylinder Diesel engine (type FR.2) which develops 16 h.p. at 1,500 r.p.m. This is coupled by a quadruple V-belt to a hydraulic pump of the triple-piston pattern having a working pressure of 3,000 lb. per square inch at 700 r.p.m. and a flow capacity of 7½ gallons per minute. Control of the slewing and digging rams is effected by three selectors and a regulating valve grouped together in one assembly in the cab; another selector valve gives control over the additional ram required by the trenching hoe. All the operating motions are protected from overloading by relief valves grouped for convenience in a bank below the selector valves; the valves are pre-set and sealed at the maker's works. Any oil passing out of the relief valves is returned to the reservoir.

**The Winget " Poclain " hydraulically-operated excavator mounted on a standard lorry chassis. It is made with a wide range of readily-convertible front-end equipment.**

### HYDRAULIC SLEWING

Slewing is accomplished by two single-acting hydraulic rams which operate a rack-and-pinion assembly that can rotate the superstructure through 300 deg., the racks being supported in adjustable roller guide brackets. Surge valves fitted to the cylinders damp down surges due to the momentum of the rotating equipment thereby ensuring smooth action at high speeds.

The cab is of steel throughout and is totally enclosed; access is through a hinged door at the rear. Unbreakable glass or Perspex windows provide clear vision to the front and sides as well as a limited view to the rear. An opening window at the front and a hinged panel near the engine have been provided for ventilation purposes. An adjustable seat, with backrest, has been fitted for the operator.

Excluding the chassis, the weight of the unit is approximately five tons, though this figure naturally varies with the type of equipment fitted; the counterweight is carried on an extension of the superstructure frame. The standard boom is 8 ft. 3½ in. long and, with a dipper arm 4 ft. 3½ in. in length, the face shovel can be used to a depth of 5 ft. 6 in. and discharged after filling at up to 13 ft. above ground level. With the same boom and arm the skimmer can be discharged 11 ft. 3 in. above the ground. Using the trench hoe—that is, when the machine is working backwards—it can take out vertical wall trenches behind the vehicle to a maximum depth of 9 ft. and unload the spoil at a height of 10 ft. 3 in. in the same cycle of operation; the same equipment can also be worked over the side of the chassis to dig a ditch of curved profile up to 13 ft. wide and 9 ft. deep, or a pipe trench 3 ft. 6 in. wide and up to 7 ft. 6 in. deep close to the side of a road, wall or bank.

## NEW GRINDING MACHINES

Three new grinding machines have been introduced by the Gardner Machine Company, Beloit, Wisconsin, U.S.A., whose agents in Great Britain are Burton Griffiths and Company, Limited, Mackadown-lane, Kitts Green, Birmingham 33.

For free-hand grinding of single flat surfaces on many different types of small component the vertical-spindle disc grinder shown in Fig. 1 is produced. It has an 18-in. diameter grinding wheel driven by multiple V-belts from a 5-h.p. motor enclosed in the base of the machine. A simple hand-operated bar-type wheel dresser is provided. An outlet for attaching a dust-collecting system is built into the machine base.

The machine shown in Fig. 2 is specially designed for high-production grinding of the closed ends of automobile tappets. Two grinding heads, working on ball-bearing ways, are provided, and the heads have automatic feed with provision for manual feed as required. Ball and roller bearings are used to carry the grinding spindles. Each head pivots to adjust the angularity of the grinding wheel. A power-operated swinging dresser is provided for each head.

Tappets to be ground are fed from a hopper to an inclined chute, from which they are picked, one by one, by a rotary work-carrier of the V-notch type, with variable-speed drive. A chain hold-down attachment retains the tappets in position during grinding and releases them when the operation is complete for discharge by gravity. A caliper on each head registers from the ground surface and moves the head inwards when insufficient stock is being removed. The machine is capable of grinding 2,400 tappets an hour, with 0·028 to 0·038 in. maximum stock removal.

Grinding of two parallel faces of small components simultaneously is possible on the machine illustrated in Fig. 3. It has two 18-in. diameter abrasive discs driven by 5-h.p. totally-enclosed motors and mounted coaxially on a heavy cast-iron column. The abrasive discs are solid, with no centre holes, and work can thus be moved past the centres of the wheels to make the fullest possible use of the grinding area. A hand-operated swinging-arm wheel dresser is mounted on the column.

Work-pieces are loaded by hand into openings in a circular, horizontally-mounted, power-driven work carrier. Quick change-over of work carriers is possible as they are held in position by a single clamping screw. Variable-speed drive is provided for the work carrier, and speeds ranging from $\frac{1}{8}$ to 1 r.p.m. are available.

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## PRODUCING MASTERS FOR OPTICAL PROJECTORS

### *A Precision Layout Fixture*

The production of masters for optical projectors is simplified and speeded-up by the Aldridge layout fixture, which has been developed by the Aldridge Tool and Engineering Company, Limited, and is marketed exclusively by Alfred Herbert, Limited, Edgwick, Coventry. The fixture is of simple design and can be used by anyone possessing a basic knowledge of trigonometry and able to use a vernier height-gauge and a vernier protractor.

The instrument incorporates a protractor head which can be rotated through 360 deg. and carries, in an easily-removable frame at the front, a rectangular sheet of Perspex forming a screen similar in size to that used on the Hilger universal projector. The layout fixture can also be supplied to suit screens of different sizes if required. The protractor head is equipped with a spring-loaded plunger to locate it accurately at 15-deg. intervals, and has an angular vernier graduated in minutes so that it can be set to any other angle desired. It is thus possible to produce the final layout required on a sheet of specially-prepared material held on the protractor head by using an ordinary vernier height-gauge and rotating the head.

To set out a master, the dimensions on the drawing of the component are first multiplied by a predetermined constant to give the required magnification. The approximate outline of the magnified form is then sketched on a sheet of graph paper, with pencilled notes to indicate the relative positions of the various planes and radii. The metal frame is next removed from the fixture and a sheet of layout material is placed on the Perspex screen. The recommended layout material, which is specially made, is transluscent and light-diffusing, and is sufficiently durable to withstand normal shop use. The material adheres to the Perspex on being smoothed down with a brush or a piece of cloth. When the material is in position the graph paper is placed behind the screen and the metal frame is replaced on the fixture. Finally, a vernier height-gauge is used to scribe the outline of the required magnified form into the surface of the layout material, using the notes and sketched outline as a guide, and rotating the head as required. The layout is completed by adding radii with a pair of dividers and rubbing a little micrometer blue into the scribed grooves to increase their visibility. The projection layout thus formed is a permanent record, and may be stored for long periods in an even temperature without loss of accuracy.

**Producing a master layout for use with an optical projector. The layout lines are scribed with a vernier height-gauge into the surface of a specially-prepared material held on a swivelling head.**

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## MOTOR INDUSTRY SUMMER SCHOOL

The ninth annual residential summer school of the Institute of the Motor Industry will be held from Saturday, August 20, to Saturday, August 27, 1955, at Corpus Christi College, Cambridge.

Subjects dealt with at the last school included management, economics, industrial relations, accountancy and commercial practice, practical financial controls, the principles of law, and sales promotion, and were based on the preferences of the students. It is proposed to adopt a similar method next year.

Attendance is open to all men and women engaged in the motor industry and further information may be obtained from the Institute, 40 Queen's Gate, London, S.W.7.

**Fig. 1 Horizontal disc-grinder with 18-in. diameter wheel.**

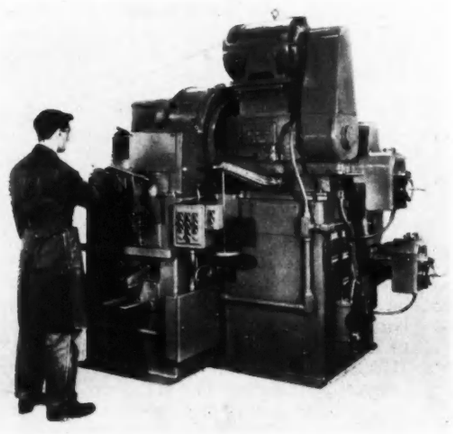

**Fig. 2 Horizontal-spindle two-head machine for grinding valve tappets.**

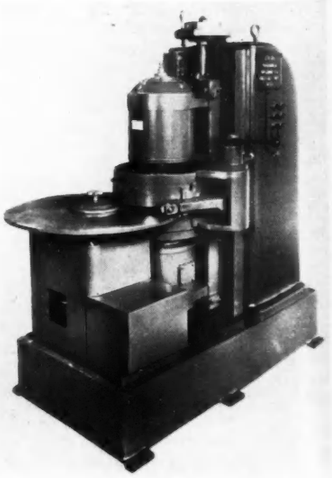

**Fig. 3 Two-head machine for simultaneous grinding of two parallel faces.**

## LOCOMOTIVE WEIGHING MACHINE

An improved locomotive weighing machine has been installed at the Crewe works of the London Midland Region. The machine, which is illustrated below with a locomotive in position, is used to enable the load on each wheel to be set to the correct value by adjusting the spring appropriately. Every locomotive leaving the works after repair or when new is weighed in this way and a record kept of the wheel loads. It is of interest to note, however, that although every care is taken to achieve the correct adjustment, the individual loads can change slightly even by running the engine for a few yards and then bringing it back to the weighing machine. This variation is caused by the considerable friction and stiffness inherent in the locomotive suspension, etc.

The machine has been designed and built by Henry Pooley and Son, Limited, Digbeth, Birmingham, 5, and is capable of accommodating all classes of British Railways locomotives. The complete unit consists of seven pairs of tables each 7 ft. in length, spaced ½ in. apart, giving 14 individual wheel weighing units, each of which has a weighing capacity of 20 tons and registers on a dial indicator graduated in 1-cwt. divisions.

The principal features of the installation are: (*a*) The elimination of dead sections between each pair of tables. (*b*) The immediate indication of all wheel weights on the dial indicators, enabling the operator to observe the weight variations as spring adjustments are made. (*c*) Locomotives are positioned centrally on the rails by the provision of check rails on each table. (*d*) A walkway is provided down the centre of the tables; this is 2 ft. 6 in. deep, 1 ft. 4 in. wide at the lower part opening out to 2 ft. 3 in. at the top, and is equipped with fluorescent lighting. (*e*) All the dial indicators are fitted with a coupled relieving mechanism, and are put in gear by the operation of a centrally placed lever; illumination of the dials is supplied by fluorescent-light fittings.

The machine is in a building equipped with modern lighting, roof vents, and sliding doors.

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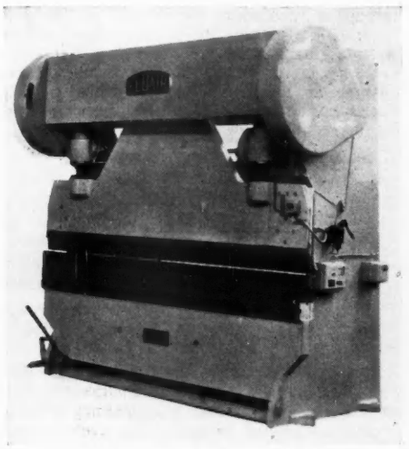
## FELL DIESEL-MECHANICAL LOCOMOTIVE

The only main line Diesel-mechanical locomotive in this country—the Fell locomotive—has gone into service again on Derby-Manchester passenger trains after an absence of 16 months. The locomotive first made its appearance on January 21, 1952, but was withdrawn later for modification and general trials.



**The new addition to the Eldair range of press brakes exerts a pressure of 110 tons and can deal with plates up to a maximum of 12 ft. long by ½ in. thick.**

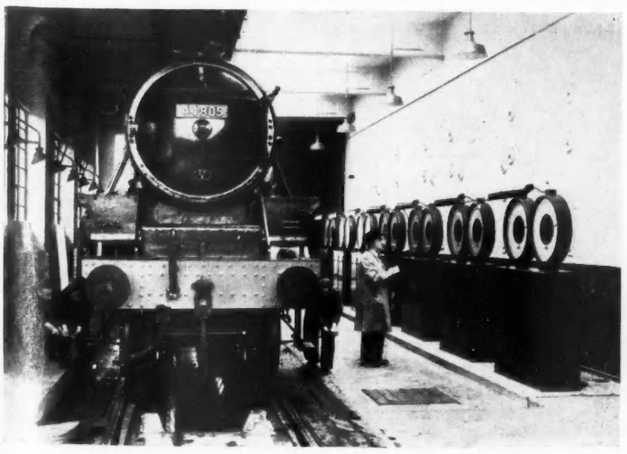
## 110-TON PRESS BRAKE

### *An Addition to the Eldair Range*

An addition to the Eldair range of press brakes made by Weldall and Assembly, Limited, Stourbridge, Worcestershire, is the 110-ton model illustrated herewith. It has a forming capacity in mild steel of 8 ft. by ½ in. between the frames, and 10 ft. by $\frac{3}{16}$ in. when using the overall die length. The machine can also be supplied to deal with plate 4 ft. by ⅝ in., 6 ft. by $\frac{3}{16}$ in., 10 ft. by $\frac{1}{4}$ in., or 12 ft. by ⅜ in. It is capable of making 30 strokes a minute, with a standard stroke of 3 in. and a ram adjustment of 5 in. The maximum die space is 12 in. with the press at the bottom of its stroke.

The top beam and bed of the machine are cut from solid steel slabs, with forged-steel ball-joint cups welded to the beam. A three-bearing crankshaft is fitted, with one bearing in the side frame to take the gear load, and two in the central crown to take the load imposed by plate bending. The slides are of V-form, adjustable to take up wear, and are lubricated, together with all the main bearings, by a central "one-shot" lubricator. Grease nipples are provided for the clutch, flywheel and ram-adjusting worm gears.

Control of the press is by a pedal or a hand-lever, which are mounted so that they can be set at any point along the length of the machine. They operate a multi-plate friction clutch. As an alternative, a pneumatically-operated clutch can be provided, with a portable pedal control.



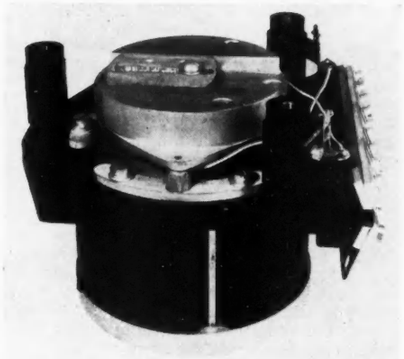
**Locomotive weighing machine installed at Crewe works. As the load on each wheel is adjusted the value is indicated on the corresponding dial.**

## REFRACTION GEOPHONE

### *Instrument for Seismic Surveying*

A geophone now being made by Oliver Pell Control, Limited, Cambridge-row, London, S.E.18, is claimed to be both smaller and lighter than earlier models. The instrument was developed at the research station of the Anglo-Iranian Oil Company, Limited, Kirklington Hall, near Newark, Nottinghamshire. The geophone is an instrument used in seismic surveying for recording shock waves set up by explosions. As the waves pass through the different ground formations they are refracted by them and their time of arrival is altered. The geophone pick-up vibrates with the waves and generates an electric-signal which is recorded on another instrument. As much as 2 or 3 tons of dynamite may be used to give records at 60,000 ft. from the point of explosion, although the instrument will record ground displacements of about $5 \times 10^{-9}$ cm. The frequencies of such shocks lie between 2 and 30 cycles per second. This model has a moving-coil velocity-type pick-up of high sensitivity and with a natural frequency of 1·8 cycles per second. When using a 200-ohm coil the sensitivity factor is approximately 1 volt per centimetre per second.

In the new instrument, which is shown in the illustration below, the moving coil is mounted at the free end of a beam which has its other end hinged to a wide flat spring. This gives a



**Designed for light weight and robustness, this geophone, shown removed from its case, has a high sensitivity and a low natural frequency.**

high sensitivity to vertical motion and a low sensitivity to horizontal movement. It also allows a compact instrument to be made, as an equivalent helical spring would be 4 or 5 in. long. The complete instrument, in its cast-aluminium carrying case, weighs 13 lb., of which the magnet assembly and the inertia mass make up the greater part. The whole is designed for rough usage in the field, and the movement can be clamped by a single turnscrew in the lid to protect it from damage during transit. This screw passes through a waterproof gland and can be removed to allow visual inspection of the equilibrium position of the inertia mass and for any necessary adjustment of it to be made by means of a rider.

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## BUILDING PLANT EXHIBITION GLASGOW, JUNE, 1955

The 1955 Building Plant Exhibition, organised by the Ministry of Works, will be held in Glasgow from Wednesday, June 8, until Wednesday, June 15, inclusive. It will be held on the Queenslie Industrial Estate adjoining the Glasgow to Edinburgh main road, about 3½ miles from the city centre. Adjoining the Exhibition site is an area of rough ground suitable for the demonstration of every kind of plant.

**2,000-kVA electric arc furnace in which the electrodes are regulated hydraulically.**

## 2,000-KVA ELECTRIC ARC FURNACE

### *Hydraulically Controlled Electrodes Improve Efficiency*

The accompanying illustration shows a 2,000-kVA electric arc furnace which has been installed by G.W.B. Furnaces, Limited, Dudley, Worcestershire, in the works of the Clyde Alloy Steel Company, Limited, Motherwell. It has been designed by the firm of Ing. L. Tagliaferri and C., of Milan, and incorporates a hydraulic system of electrode regulation to obtain both high speeds and rapid acceleration.

This hydraulic system comprises two electrically driven pumps, one of which acts as a standby. These pumps are installed in a sump, which supplies water to an accumulator tank, this tank being connected to a compressed air bottle so that any variations in pressure which occur are damped out. Compressed air is also used to raise the electrodes in event of a failure of the electricity supply.

The pumps are connected through piston valves which, when they are in their upper positions, admit water to rams thus causing the graphite electrodes, which are 8 in. in diameter, to be lifted. When the valves are in their lowered positions water is released from the rams, so that the electrodes are lowered by gravity. In the intermediate positions of the valves the electrodes are maintained stationary.

Automatic operation of the valves, and thus of the rams and electrodes, is effected by solenoids, the coils of which are supplied through current transformers from the main low tension bus-bars, so that the current through them varies with that across the arc caused by the state of the charge. Armatures connected to the solenoid cores are pivoted on the stems of oil control valves and are held against the magnetic pull by springs. Any variation in the electrode current causes the control valves to rotate, their motion being transmitted to the hydraulic system by stirrups. Changes in the arc current thus bring about corresponding changes in the positions of the electrodes.

The same hydraulic system provides the power necessary for tilting the furnace body, lifting and swinging aside the roof and raising the door. This method of operating the roof speeds up loading, which is carried out by a drop-bottom steel charge basket. The electrodes themselves are held in position by spring-loaded clamps which can be released by the hydraulic pressure. Maintenance work on the top of the hot furnace is thus reduced to a minimum.

The furnace is supplied from the 6·6-kV mains through a transformer, the average melting time for a 3-ton charge being 2·16 hours. The electricity consumed is 650 kWh per ton of metal melted and only 10 lb. of electrode per ton of metal are used. The charges consist of mild steel scrap and turnings and the output is used for the production of high quality castings.

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## MEASUREMENT AND CONTROL OF FLUID LEVEL

### *Apparatus for Molten Glass*

Accurate measurement and control of fluid level is essential in many industries, and is particularly important in glass-making when a continuous process is used. The level of glass "metal" in the glass-melting tank must be kept steady if consistency in capacity and weight of the finished product are to be maintained. Two firms have co-operated in developing a system of level measurement which will detect and record changes of level of a few thousandths of an inch and yet meet the severe conditions associated with glass manufacture. The two firms are the Hartford-Empire Company, Limited, Connecticut, U.S.A., and George Kent, Limited, Luton, England.

As illustrated in the accompanying diagram, a stationary electrode is immersed in the glass in the forehearth of one of the feeders, while a travelling electrode is raised and lowered by a motor-driven gearbox. An electrical transmitter geared to the travelling electrode sends signals to the receiver of the recorder, indicating the electrode's position. The two electrodes are energised by a low-voltage alternating-current supply, so that when the travelling electrode is raised and then lowered to the point where its tip touches the glass surface, the electrical circuit is completed and energises a time-delay relay. This causes the travelling electrode to be held stationary for a few seconds, while the Multelec recorder mechanism is switched into operation. After the recording has been made, the geared drive is reversed, raising the travelling electrode to the point where it breaks contact with the glass surface. The drive is then immediately reversed once more and the electrode lowered to commence a new cycle. The accompanying illustration shows the motor-driven gearbox end of the equipment.

An indicator lamp lights each time the travelling electrode is in contact with the glass surface, and besides indicating that normal recording is proceeding, this feature may be used as a means of indicating the position of the glass level if continuous recording is not required. The procedure is to lower the travelling electrode by means of a handwheel until the lamp lights, and the level is then read off on an engraved scale.

Additional features include an alarm to call attention to a breakdown in the recording cycle, adjustable high- and low-level alarm contacts, a magnetically-braked motor drive eliminating overdrive of the travelling electrode, and a safety clutch.

The level recorder can be used to control the glass "metal" level by regulation of the rate of batch charging. Suitable types of mechanism are added to the recorder for different types of chargers.

In the case of a continuously running screw-type charger, in which the speed of rotation of the screw feeding the batch into the furnace is varied, the Multelec recorder is fitted with a Mark 20 pneumatic controller. A power cylinder is used to operate the existing speed regulator of the variable-speed driving mechanism.

**Motor-driven gearbox end of the equipment, showing pilot light that indicates normal recording is proceeding.**

For pusher-type chargers, which run to a predetermined cycle fixed by electrical timers operating the starters of the charger motors, it is simply necessary to initiate the cycle as often as required to maintain the correct level. For this purpose, the Multelec is equipped for "on-off" control.

Close control of tank pressure is essential because changes in tank pressure directly affect the "metal" level in the forehearths, quite apart from their effect on combustion in the tank. To illustrate this point, the plant may be considered as a manometer, one leg of which is the tank, subjected to furnace pressure, and the other the combined forehearths, which are open to atmosphere. Increase in tank pressure will cause an increase in glass level in the forehearths. Moreover, owing to the difference in surface area of the two "legs," any change of level in the tank will be magnified, possibly as much as ten times, in the forehearths.

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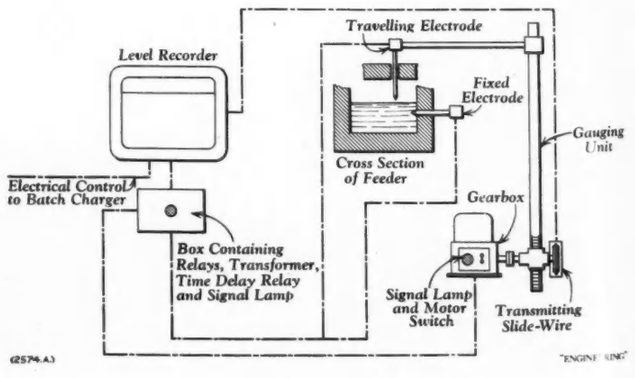
## SULPHURIC ACID PLANT

The rotary kilns, shaker conveyors and jaw crushers of the sulphuric acid plant described in ENGINEERING for November 12 (page 640) were supplied by Edgar Allen and Company, Limited, Imperial Steel Works, Sheffield 9. The kilns are 355 ft. long and constitute the principal part of this plant, which produces cement as well as sulphuric acid.




**Diagrammatic scheme of measurement of glass level. By suitable additions to the recorder the glass "metal" level can be controlled as well as measured.**

*Labour Notes*

# LATER PENSION AGES PROPOSED

Suggestions for raising the minimum pension age to 68 for men and to 63 for women are contained in the report of the Committee on the Economic and Financial Problems of the Provision for Old Age, which was published last Friday. (Cmd. 9333, H.M.S.O., price 4*s*. net.)

The committee, which was appointed by the Chancellor of the Exchequer, Mr. R. A. Butler, in July, 1953, comprised a number of persons of economic and actuarial ability, and included representatives of the Trades Union Congress. It was presided over by Sir Thomas Phillips, who was formerly Permanent Secretary to the Ministry of National Insurance.

The most outstanding proposals of the committee are that, owing to the prospects of a large increase in the cost of old-age pensions payable under the national insurance scheme, provision should be made immediately to raise pension ages by one year after an interval of not less than five years, and by two further increases of one year at subsequent intervals.

A suggestion that the present difference of five years between the pensionable ages of men and women should be abolished was considered by the committee and rejected.

## LIMITED VALUE OF PROPOSALS

Emphasis is placed by the committee on the fact that existing pension ages do not by any means represent the limit of the working lives of the recipients and that many people receive pensions some time before reaching old age in the physical sense.

At the same time, the committee recognises that, although there would be a reduction in the number of pensioners if pension ages were raised, it is important not to exaggerate the net financial effect.

For example, during the years between the existing pensionable ages and the new minimum ages, unemployment and sickness benefits would be payable in appropriate cases. These amounts, which for persons in those age groups would be certainly higher than the average, would more than counter-balance the contributions paid during that period by the old people.

If the minimum pension ages were raised now to 68 for men and 63 for women, the committee points out, there would be a gross annual saving in expenditure on pensions rising to about £125 million in 1979-80. The net saving, however, would be only about £50 million or, roughly, one-seventh of the total deficit on pensions expected in that year.

The Government Actuary's estimate of the cost of retirement pensions, based on existing rates of benefit, was £665 million in the year 1979-80.

## OPPOSITION FORESEEN

The committee regards resistance to its suggestions as being inevitable. In this connection, the committee states that it is fully conscious that any such proposal is likely to meet with "strenuous and sincere" opposition, but, it adds, financial facts must be faced. Although increases in the minimum pension ages would not solve the financial problem involved in the paying of old-age pensions, it would make a substantial contribution.

No change is proposed by the committee in the existing provisions of the national-insurance scheme, whereby retirement pensions are payable at the age of 70 for men and 65 for women, whether or not the claimant has retired from work. But it will follow, the committee notes, that the present period of five years, during which pension increments can be earned, will be reduced.

It is stated in the report that some three million people are covered by superannuation schemes in the public services and probably another five million persons by industrial and commercial schemes. The committee regards the development of such schemes as desirable and feels that the risk that funds accumulating in pension schemes might prove to be too large for the country's economy to absorb is not a serious danger.

As a substantial proportion of the cost of occupational pension schemes is borne by the Exchequer by way of tax relief, the committee considers that it would be reasonable to require that, in general, the provisions of these schemes should not conflict with national policy.

Superannuation schemes, it is recommended, should take into account variations in the rate of national pensions, so as to ensure that the combined income from both sources should not exceed a certain level. This might be fixed at two-thirds of a person's final salary, or its equivalent, suitably modified in the case of workpeople whose final wages were low.

## MINORITY VIEWS

Unanimity is not a feature of the committee's report. No fewer than five of its ten members make reservations of one sort or another.

Dr. Janet Vaughan considers that there are no convincing reasons why the minimum pensionable age should be lower for women than for men and Mr. F. J. C. Honey rejects the committee's recommendation that contributions should be raised more in proportion than increases in benefits.

The two trade-union members, Mr. C. Bartlett and Mr. A. McAndrews, record their objections to any raising of the pensionable ages, either in the national-insurance scheme or in private schemes. They disagree with the view that the pension burden will become heavy enough to justify the small saving to be gained by raising the age by three years.

They state, in this connection, that, so far from a necessity for raising ages, there may well be a case for earlier retirement from the more arduous occupations.

Professor A. K. Cairncross feels that if the pensionable age is raised to 68 for men, no real advantage will be gained by applying to pensioners of 68 and 69 the three rules which have never been applied to men pensioners aged 70 and over; namely, making retirement compulsory, reducing their pensions for earnings during retirement, and granting increments for deferred retirements. In his view, these features of the scheme should be abolished, even if the pensionable age is kept at 65.

## DOCK EMPLOYEES SEEK INCREASED PAY

Under the terms of the national dock labour scheme, attendance money is paid from a central fund to all registered port employees who report for work and for whom no employment is found. Similarly, men whose earnings in any week fall short of the minimum rate, guaranteed under the scheme, have their wages brought up to that amount from the same fund, provided that they have reported for work on each day during the period. The fund is maintained from a levy on port employers and based on the wages paid by each firm.

Claims for a higher rate of attendance money and for an increase in the guaranteed minimum wage were presented by the leaders of unions representing dock employees to the National Association of Port Employers on December 2. It is understood that the new demands had been under consideration for some time and that unanimity of views had been reached between the unions concerned.

The National Amalgamated Stevedores and Dockers, which has taken part in previous negotiations of this character, was not a party to the demands and was not represented at the meeting.

In spite of this, any concession granted as a result of the claims will be applied to all dock employees, irrespective of the particular union to which they belong.

The negotiations were adjourned and another meeting is expected to be held in the near future, after the employers have had an opportunity to consider the case put forward by the unions. About 70,000 dock workers are affected.

## RAILWAY WAGE SITUATION

A somewhat harsher note has been struck in connection with the negotiations on a further wage increase for railwaymen, other than the footplate and salaried grades, and the union concerned, the National Union of Railwaymen, has asked for an early meeting with Mr. J. A. Boyd-Carpenter, the Minister of Transport and Civil Aviation, in view "of the dangerous wage situation" on the railways.

This course was decided upon by the union's executive committee last Monday after discussions between the union's leaders and Sir Brian Robertson, chairman of the British Transport Commission. The union had made it plain to Sir Brian that they intended to press for the balance of their original claim for an increase of 15 per cent. for the grades concerned.

That claim was presented over a year ago and has been met, in part, by increases in December, 1953, and in January and October last. These increases have brought the amount conceded by the Commission to between 8 and 9 per cent. Sir Brian is understood to have emphasised that the Commission regarded the settlement agreed by the union in October as finally disposing of the original claim, and to have suggested that a new claim should be presented, but he was unable to commit the Commission to giving it favourable consideration. It is the union's contention that the Government should give financial help to the Commission.

## CHANGES IN WAGE RATES

About 1,466,000 workpeople in the United Kingdom benefited to the extent of approximately £381,000 from increases in their basic wage rates, which came into operation during October. There was a decrease of about £4,700 in the full-time weekly wages of 184,000 other persons during the same period.

The principal increases affected employees of British Railways, other than locomotive-running staffs, employees in the cotton industry, distributive and ancillary workers employed by retail co-operative societies, and persons engaged in furniture manufacture. Other classes of workpeople receiving increases included certain grades of non-skilled employees at many Government industrial establishments and persons employed on the transport of goods by road.

The decreases in wage rates, which came into force under certain sliding-scale arrangements based on the index of retail prices, affected mainly operatives in the iron and steel industry.

Of the total increase of £381,000 a week, about £192,000 resulted from direct negotiations between employers and workpeople, or their representatives; and about £109,000 was the result of arbitration awards.

# NOTICES OF MEETINGS

### Aslib

LONDON
"Advances in Classification," by Dr. G. Malcolm Dyson and B. C. Vickery. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Fri., Dec. 17, 6 p.m.

### Association of Supervising Electrical Engineers

LONDON
"Atomic Energy," by R. A. Dixon. Central London Branch. St. Ermin's Hotel, Caxton-street, S.W.1. Mon., Dec. 13, 7 p.m.
"Modern Lighting Technique," by R. Pye. South-West London Branch. 32 Worple-street, Wimbledon, S.W.18. Wed., Dec. 15, 8.15 p.m.
MANCHESTER
"Electrical Generation by Wind Power," by Lord Verulam. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Dec. 14, 7 p.m.
NOTTINGHAM
American Industrial Films. Nottingham Branch. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Wed., Dec. 15, 7.30 p.m.
OXFORD
"Earth Leakage Protection," by J. A. Robbins. Oxford Branch. 10 George-street, Oxford. Sat., Dec. 18, 6.30 p.m.

### Chemical Engineering Group

LONDON
"Drying of Wheat Grain," by Professor Ewan McEwan, and others (six papers). Geological Society, Burlington House, Piccadilly, W.1. Tues., Dec. 14, 5.30 p.m.

### Chemical Society

LONDON
"Newer Aspects of the Organic Chemistry of Nitrogen," by Professor G. R. Clemo. Thurs., Dec. 16, 7.30 p.m.

### Diesel Engine Users Association

LONDON
"Report on Heavy-Oil Engine Working Costs and Performance, 1953"; and Discussions on "Operating Problems" and "Faults in Existing Fuel-Injection Systems." Annual General Meeting. Caxton Hall, Westminster, S.W.1. Thurs., Dec. 16, 2.30 p.m.

### Illuminating Engineering Society

LONDON
"Maintenance of Lighting Installations," by J. Mortimer Hawkins, W. Robinson and J. W. Strange. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Dec. 14, 6 p.m.
LIVERPOOL
"Stage Lighting," by P. Corry. Liverpool Centre. College of Art, Hope-street, Liverpool. Tues., Dec. 14, 7 p.m.
SHEFFIELD
Presidential Address by E. C. Lennox. Sheffield Centre. The University, Western Bank, Sheffield, 10. Mon., Dec. 13, 6.30 p.m.

### Incorporated Plant Engineers

BIRMINGHAM
Film Evening. Birmingham Branch. Imperial Hotel, Birmingham. Fri., Dec. 17, 7.30 p.m.
DUNDEE
"Feedwater Treatment," by E. L. Streatfield. Dundee Branch. Mathers Hotel, Dundee. Mon., Dec. 13, 7.30 p.m.
GLASGOW
"Steam for Process," by L. G. Northcroft. Glasgow Branch. 425/427 Sauchiehall-street, Glasgow. Wed., Dec. 15, 7 p.m.
LIVERPOOL
"Progress in Lamps and Lighting," by R. V. Mills. Merseyside and North Wales Branch. Radiant House, Bold-street, Liverpool. Thurs., Dec. 16, 7.15 p.m.
ROCHESTER
"Gamma-Ray Examination of Pressure Welds," by E. Marson and H. Webborn. Kent Branch. Bull Hotel, Rochester. Wed., Dec. 15, 7 p.m.
SWANSEA
Discussion on "Vacuums and Air in Industry." South Wales Branch. Mackworth Hotel, Swansea. Tues., Dec. 14, 7.15 p.m.

### Institute of British Foundrymen

LONDON
"Melting and Casting Under Reduced Pressure," by Dr. H. H. Scholefield. London Branch. 4 Grosvenor-gardens, S.W.1. Thurs., Dec. 16, 7 p.m.
BIRMINGHAM
"Use of the 'Pop-Off' Type Moulding Box in the Mechanised Production of Light Castings," by A. J. Crook. Birmingham Branch. Grand Hotel, Birmingham. Wed., Dec. 15, 7.15 p.m.
COVENTRY
"The Hardening of Moulds and Cores by the Carbon Dioxide Process," by Dr. D. V. Atterton. Coventry Section. Coventry Technical College, Coventry. Tues., Dec. 14, 7.30 p.m.

### Institute of Fuel

BIRMINGHAM
"Social and Industrial Consequences of the Presence of Sulphur in Fuels," by Dr. A. Parker. Midland Section. Imperial Hotel, Temple-street, Birmingham. Thurs., Dec. 16, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Experience with Spreader Stokers," by T. H. Lindsay and P. Pilkington. North-Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Dec. 13, 6.30 p.m.

### Institute of Marine Engineers

LONDON
"Fuel Features Relating to Operating Experiences in Motorships Using Low-Cost Fuel," by H. F. Jones, D. Royle and R. G. Sayer. Tues., Dec. 14, 5.30 p.m.

### Institute of Metals

LONDON
"Melting and Casting under Reduced Pressure," by Dr. H. H. Scholefield. London Local Section. Thurs., Dec. 16, 7 p.m.
GLASGOW
Discussion on "Casting, Fabrication and Testing." Scottish Local Section. 39 Elmbank-crescent, Glasgow, C.2. Mon., Dec. 13, 6.30 p.m.
SHEFFIELD
"Park Gate 11-in. Continuous Bar Mill" by W. Udall. Sheffield Local Section. University Building, St. George's-square, Sheffield. Mon., Dec. 13, 7.30 p.m.

### Institute of Physics

LONDON
"X-Ray Fluorescence Analysis," by E. F. Priestley. Non-Destructive Testing Group. Fri., Dec. 17, 6.30 p.m.

### Institute of Road Transport Engineers

LONDON
"Automatic Chassis Lubrication," by S. H. Edge. Royal Society of Arts, John Adam-street, W.C.2. Thurs., Dec. 16, 6.30 p.m.
BIRMINGHAM
"Vehicle Insurance and Accident Assessment," by H. M. Gane. Midlands Centre. Crown Inn, Broad-street, Birmingham. Tues., Dec. 14, 7.30 p.m.
LEEDS
"The 'Saro' Lightweight Body," by C. E. Butterfield. Yorkshire Centre. Hotel Metropole, King-street, Leeds, 1. Thurs., Dec. 16, 7.30 p.m.
MANCHESTER
Discussion on "Tools and Equipment for Use in Workshops." North-West Centre. Engineers' Club, Manchester. Mon., Dec. 13, 7.30 p.m.

### Institute of Welding

SLOUGH
"Use of Oxygen in Industry," by E. Ryalls. North London Branch. Community Centre, Slough. Tues., Dec. 14, 7.30 p.m.

### Institution of Chemical Engineers

LEEDS
"The Adiabatic Absorption of Hydrogen Chloride," by T. A. Kantyka and H. R. Hinchcliff. North-Western Branch. The University, Leeds. Thurs., Dec. 16, 7 p.m.

### Institution of Civil Engineers

LONDON
Unwin Lecture on "Experimental Science and Civil-Engineering Research," by Dr. F. M. Lea. Tues., Dec. 14, 5.30 p.m.
PRESTON
"Work of the Road Research Laboratory," by Dr. A. Lonsdale. North-Western Association. Country Hall, Preston. Wed., Dec. 15, 5.45 p.m.

### Institution of Electrical Engineers

LONDON
Discussion on "Practical and Economic Problems in the Maintenance of Domestic Television Receivers," opened by W. L. Greenwood. Radio Section. Mon., Dec. 13, 5.30 p.m.
"An Attracted-Disc Absolute Voltmeter," by G. W. Bowdler; "The Use of an Electron Velocity Analyser to Stabilise a 50-kV Direct-Current Voltage Source to a Few Parts in a Million," by M. E. Haine and M. W. Jervis; and "A Precision Direct-Current Stabiliser," by M. W. Jervis. Measurements Section. Tues., Dec. 14, 5.30 p.m.
"Short-Circuit Forces on Turbo-Alternator End Windings," by J. B. Young and D. H. Tompsett. Supply Section. Wed., Dec. 15, 5.30 p.m.
CHESTER
"Safety in the Use of Portable and Transportable Electrical Equipment in Industry," by J. W. Bunting. Mersey and North Wales Centre. Town Hall, Chester. Mon., Dec. 13, 6.30 p.m.
LEEDS
Discussion on "The Place of Electrical Network Theory in Electrical Courses," opened by Dr. G. S. Brayshaw. North Midland Centre. 1 Whitehall-road, Leeds. Tues., Dec. 14, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Short-Circuit Forces on Turbo-Alternator End Windings," by J. B. Young and D. H. Tompsett. North-Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Dec. 13, 6.15 p.m.
NOTTINGHAM
Faraday Lecture on "Courier to Carrier in Communications," by T. B. D. Terroni. East Midland Centre. Albert Hall, Nottingham. Thurs., Dec. 16, 6.30 p.m.

### Institution of Engineering Inspection

BRISTOL
"Inspection in the Motor Industry," by A. J. Peppiatt. South-Western Branch. Grand Hotel, Broad-street, Bristol. Tues., Dec. 14, 7.30 p.m.

### Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"High-Pressure Boilers," by T. Carlile. Tues., Dec. 14 7.30 p.m.

### Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Social and Industrial Consequences of the Presence of Sulphur in Fuels," by Dr. A. Parker. Birmingham Branch. Imperial Hotel, Birmingham. Thurs., Dec. 16, 6.30 p.m.
GLASGOW
"Corrosion in Small Boilers," by J. C. Stainton. Scottish Branch. 425 Sauchiehall-street, Glasgow. Tues., Dec. 14, 7 p.m.
LEEDS
"Fuels for the Smaller Boiler Plant," by H. Pollard and B. Stonham. Yorkshire Branch. Wed., Dec. 15, 7.30 p.m.
MANCHESTER
"Atmospheric Pollution and the Soiling of Textiles," by W. H. Rees. Manchester Branch. Engineers' Club, Albert-square, Manchester. Fri., Dec. 17, 6.30 p.m.

### Institution of Mechanical Engineers

LONDON
"Problems in Lubrication and the Substances Called Additives," by A. Towle. Automobile Division. Tues., Dec. 14, 5.30 p.m.
Discussion on "It is Often Said, Usually by 'Scientists,' that Industry is Slow to Apply New Scientific Discoveries and Data, Both in Regard to Materials and Design. Is this True of the Internal Combustion Engine World?" Internal Combustion Engine Group. Thurs., Dec. 16, 6.45 p.m. Thomas Hawksley Lecture on "Recent Studies of Metallic Friction," by Dr. F. P. Bowden. Fri., Dec. 17, 5.30 p.m.

### Institution of Production Engineers

LONDON
"Budgetary Control at Shop Floor Level," by F. T. Hunter. Royal Empire Society, Northumberland-avenue, W.C.2. Thurs., Dec. 16, 7 p.m.
BIRMINGHAM
"Shell Moulding," by A. N. Wormleighton and G. Hannaford. Birmingham Section. James Watt Memorial Institute, Birmingham. Wed., Dec. 15, 7 p.m.
DONCASTER
Informal Discussion. Doncaster Section. Danum Hotel, Doncaster. Tues., Dec. 14, 7 p.m.
GLASGOW
"Work Measurement," by Professor T. U. Matthew. Glasgow Section. 39 Elmbank-crescent, Glasgow, C.2. Thurs., Dec. 16, 7.30 p.m.
LINCOLN
"Material Utilisation," by F. Nixon. Lincoln Section. Ruston Club, Unity-square, Lincoln. Thurs., Dec. 16, 7.30 p.m.
SHEFFIELD
"Welding in the Atomic-Energy Project," by I. H. Hogg. Sheffield Section. Grand Hotel, Sheffield. Mon., Dec. 13, 6.30 p.m.
SOUTHAMPTON
"Impact of United States-Financed Companies on British Productivity," by J. H. Dunning. Southern Section. Polygon Hotel, Southampton. Thurs., Dec. 16, 7.15 p.m.

### Institution of the Rubber Industry

LONDON
"Compounding of Vinyl Polymers," by S. Mottram; and "Polymer-Modified Natural Rubber," by Dr. F. M. Merrett and R. I. Wood. 26 Portland-place, W.1. Tues., Dec. 14, 5.30 p.m.
BIRMINGHAM
"Moulds and Moulding of Miscellaneous Rubber Ware," by F. Skelton. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Dec. 13, 6.45 p.m.

### Institution of Structural Engineers

LONDON
"Fabrication and Erection of Steel-Plate Girder Railway Bridges," by M. F. Palmer. Thurs., Dec. 16, 6 p.m.
LEEDS
"Lackenby Steelworks," by A. P. Clark and T. V. Thompson. Yorkshire Branch. Great Northern Hotel, Leeds. Wed., Dec. 15, 6.30 p.m.

### Junior Institution of Engineers

LONDON
Open Discussion Meeting. Fri., Dec. 17, 7 p.m.
SHEFFIELD
"Post-War Developments in Coal-Face Machinery," by S. McCallum. Sheffield Section. Livesey Clegg House, Union-street, Sheffield. Mon., Dec. 13, 7.30 p.m.

### Newcomen Society

LONDON
"History of Locomotive Power Transmissions," by F. J. G. Haut. Institution of Mechanical Engineers, 1 Birdcage-walk, S.W.1. Wed., Dec. 15, 5.30 p.m.

### Royal Aeronautical Society

LONDON
British Commonwealth and Empire Lecture, by H.R.H. The Duke of Edinburgh. Church House, Great Smith-street, S.W.1. Thurs., Dec. 16, 5.15 p.m. Admission by ticket.

### Society of Chemical Industry

LONDON
"Corrosion Prevention in the Telecommunications Industry," by C. E. Richards. Chemical Society, Burlington House, Piccadilly, W.1. Wed., Dec. 15, 6.30 p.m.

### West of Scotland Iron and Steel Institute

GLASGOW
"Destructive and Non-Destructive Tests," by J. M. Mowat. Fri., Dec. 17, 6.45 p.m.

**The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated.** Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Aslib, 4 Palace-gate, London, W.8. (WEStern 6321.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Diesel Engine Users Association, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Inspection, 28 Victoria-street, London, S.W.1. (ABBey 3794.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James' Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Society of Chemical Industry, 56 Victoria-street, London, S.W.1. (VICtoria 5215.)
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)